PROCEEDINGS

OF THE

Iowa Academy of Sciences

FOR 1900.

VOLUME VIII.

EDITED BY THE SECRETARY.

PUBLISHED BY THE STATE.

DES MOINES:
B. MURPHY, STATE PRINTER.
1901.

The Bra

J. C. Branner

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LETTER OF TRANSMITTAL.

AMES, Iowa, December 31, 1900.

To His Excellency, Leslie M. Shaw, Governor of Iowa:

SIR—In accordance with the provision of title 2, chapter 5, section 136, code 1897, I have the honor to transmit herewith the proceedings of the fifteenth annual session of the Iowa Academy of Sciences.

Respectfully submitted, your obedient servant,

SAMUEL W. BEYER,
Secretary Iowa Academy of Sciences.

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OFFICERS OF THE ACADEMY.

1900.

President.—W. H. Norton.
First Vice-President.—B. Fink.
Second Vice-President.—A. A. Veblen.
Treasurer.—J. B. Weems.
Secretary —S. W. Beyer.

EXECUTIVE COMMITTEE.

Ex-Officio.—W. H. Norton, B. Fink, A. A. Veblen, S. W. Beyer.
Elective —A. Marston, J. R. Sage, B. Shimek.

1901.

President.—A. A. Veblen.
First Vice-President.—H. E. Summers.
Second Vice-President.—J. L. Tilton.
Secretary.—S. W. Beyer.
Treasurer.—J. B. Weems.

EXECUTIVE COMMITTEE.

Ex-Officio.—A. A. Veblen, H. E. Summers, J. L. Tilton, S. W. Beyer, J. B. Weems.
Elective.—M. F. Arey, H. M. Kelly, C. O. Bates.

PAST PRESIDENTS.

Osborn, Herbert	1887–88
Todd, J. E	1888–89
Witter, F. M	1889–90
Nutting, C. C	1890–92
Pammel, L. H	1893
Andrews, L. W	1894
Norris, H. W	1895
Hall, T. P	1896
Franklin, W. S	1897
Macbride, T. H	1897–98
Hendrixson, W. S	1899
Norton, W. H	1900

Constitution of the Iowa Academy of Sciences.

SECTION 1. This organization shall be known as the Iowa Academy of Sciences.

SEC. 2. The object of the Academy shall be the encouragement of scientific work in the state of Iowa.

SEC. 3. The membership of the Academy shall consist of (1), fellows who shall be elected from residents of the state of Iowa actively engaged in scientific work, of (2), associate members of the state of Iowa interested in the progress of science. but not direct contributors to original research, and (3), corresponding fellows, to be elected by vote from original workers in science in other states; also, any fellow removing to another state from this may be classed as a corresponding fellow. Nomination by the council and assent of three-fourths of the fellows present at any annual meeting shall be necessary to election.

SEC. 4. An entrance fee of $3 shall be required of each fellow, and an annual fee of $1, due at each annual meeting after his election. Fellows in arrears for two years, and failing to respond to notification from the treasurer, shall be dropped from the academy roll.

SEC. 5. (*a*) The officers of the academy shall be a president, two vice-presidents, secretary and a treasurer, to be elected at the annual meeting. Their duties shall be such as ordinarily devolve upon these officers. (*b*) The charter members of the academy shall constitute the council, together with such other fellows as may be elected at an annual meeting of the council by it as members thereof, *provided*, that at any such election two or more negative votes shall constitute a rejection of the candidate. (*c*) The council shall have power to nominate fellows, to elect members of the council, fix time and place of meetings, to select papers for publication in the proceedings, and have control of all meetings not provided for in general session. It may, by vote, delegate any or all of these powers, except the election of members of the council, to an executive committee, consisting of the officers and of three other fellows, to be elected by the council.

SEC. 6. The academy shall hold an annual meeting in Des Moines during the week that the State Teachers' association is in session. Other meetings may be called by the council at times and places deemed advisable.

SEC. 7. All papers presented shall be the result of original investigation, but the council may arrange for public lectures or addresses on scientific subjects.

SEC. 8. The secretary shall each year publish the proceedings of the academy in pamphlet (octavo) form, giving author's abstract of papers, and if published elsewhere, a reference to the place and date of publication; also the full text of such papers as may be designated by the council. If

published elsewhere the author shall, if practicable, publish in octavo form and deposit separates with the secretary, to be permanently preserved for the academy.

SEC. 9. This constitution may be amended at any annual meeting by assent of a majority of the fellows voting, and a majority of the council; *provided*, notice of proposed amendment has been sent to all fellows at least one month previous to the meeting, and provided that absent fellows may deposit their votes, sealed, with the secretary.

ARTICLES OF INCORPORATION OF THE IOWA ACADEMY OF SCIENCES.

ARTICLE I.

We, the undersigned, hereby associate ourselves with the intention to constitute a corporation to be known as the Iowa Academy of Sciences, the purpose of which is to hold periodical meetings for the presentation and discussion of scientific papers, to publish proceedings, to collect such literature, specimens, records and other property as may serve to advance the interests of the organization, and to transact all such business as may be necessary in the accomplishment of these objects.

ARTICLE II.

The membership of the corporation shall consist of the incorporators, and such other residents of the state of Iowa as may be duly elected fellows of the academy.

ARTICLE III.

The duly elected officers of the academy shall be the officers of the corporation.

ARTICLE IV.

The principal place of business of the academy shall be the city of Des Moines, in the state of Iowa.

The capital stock of the corporation is none.

The par value of its shares is none.

The number of its shares is none.

ARTICLE V.

The academy shall hold an annual meeting in the last week of December, of each year, or upon call of the executive committee, and such other meetings as may be arranged for.

ARTICLE VI.

This corporation shall have the right to acquire property, real and personal, by purchase, gift or exchange, and such property shall be held subject to the action of the majority of its fellows, or the council, the executive committee, or such parties as it may by vote direct to transact such business in accordance with the constitution.

All deeds, leases, contracts, conveyances and agreements, and all releases of mortgages, satisfactions of judgments, and other obligations, shall be

signed by the president or vice-president and the secretary, and the signature of these officers shall be conclusive evidence that the execution of the instrument was by authority of the corporation.

ARTICLE VII.

The private property of the members of this corporation shall not be liable for any of its debts or obligations.

ARTICLE VIII.

By-laws, rules and regulations, not inconsistent with these articles, may be enacted by the Academy.

ARTICLE IX.

These articles may be amended at any meeting of the Academy called for the purpose by assenting vote of two-thirds of the members present.

MEMBERSHIP OF THE ACADEMY.

FELLOWS.

ALDEN, W. C. .... Mount Vernon
ALMY, F. F. .... Iowa College, Grinnell
AREY, M. F. .... State Normal School, Cedar Falls
BARRIS, W. H. .... Griswold College, Davenport
BATES, C. O. .... Coe College, Cedar Rapids
BEARDSHEAR, W. M. .... State College, Ames
BENNETT, A. A. .... State College, Ames
BEYER, S. W. .... State College, Ames
BISSELL, G. W. .... State College, Ames
CALVIN, S. .... State University, Iowa City
CHAPPEL, GEORGE M. .... State Weather Service, Des Moines
CLARK, DR. J. FRED .... Fairfield
COOK, ALFRED N. .... Morningside College, Sioux City
CRATTY, R. I. .... Armstrong
CURTISS, C. F. .... State College, Ames
DAVIS, FLOYD .... Des Moines
DENNISON, O. T. .... Mason City
ENDE, C. L. .... State University, Iowa City
FAUROT, F. W. .... State College, Ames
FINK, B. .... Upper Iowa University, Fayette
FITZPATRICK, T. J. .... Iowa City
FULTZ, F. M. .... Burlington
HADDEN, DAVID E. .... Alta
HENDRIXSON, W. S. .... Iowa College, Grinnell
HOLWAY, E. W. D. .... Decorah
HOUSER, G. L. .... State University, Iowa City
KELLY, H. M. .... Cornell College, Mt. Vernon
KEPPEL, J. T. .... Upper Iowa University, Fayette
KEYES, C. R. .... Des Moines
KING, MISS CHARLOTTE M. .... State College, Ames
KNIGHT, NICHOLAS .... Cornell College, Mount Vernon
KUNTZE, DR. OTTO .... Iowa City
LEONARD, A. G. .... Geological Survey, Des Moines
LEVERETT, FRANK .... U. S. Geological Survey, Denmark
MARSTON, A. .... State College, Ames
MACBRIDE, T. H. .... State University, Iowa City
METCALF, HAVEN .... Tabor
MILLER, B. L. .... Penn College, Oskaloosa
NEWTON, G. W. .... State Normal, Cedar Falls

NORRIS, H. W .... Iowa College, Grinnell
NORTON, W. H .... Cornell College, Mt. Vernon
NUTTING, C. C .... State University, Iowa City
O'DONOGHUE, J. H .... Storm Lake
PADDOCK, A. ESTELLA .... State College, Ames
PAGE, A. C .... State Normal, Cedar Falls
PAMMEL, L. H .... State College, Ames
REPP, JOHN J .... State College, Ames
RICKER, MAURICE .... Burlington
ROSS, L. S .... Drake University, Des Moines
SAGE, HON. J. R .... State Weather Service, Des Moines
SHIMEK, B .... State University, Iowa City
STANTON, E. W .... State College, Ames
STOOKEY STEPHEN W .... Coe College, Cedar Rapids
SUMMERS, H. E .... State College, Ames
TILTON, J. L .... Simpson College, Indianola
VEBLEN, A. A .... State University, Iowa City
WALKER, L. R .... State College, Ames
WEEMS, J. B .... State College, Ames
WICKHAM, H. F .... State University, Iowa City
WITTER, F. M .... Muscatine

ASSOCIATE MEMBERS.

ADAMS, P. E .... Durham
ALLEN, J. R .... Marble Rock
BAILEY, DR. BERT H .... Cedar Falls
BALDWIN, F. H .... Tabor
BARNES, WM. D .... Blue Grass
BEGEMAN, LOUIS .... Cedar Falls
BIERING, DR. WALTER .... Iowa City
BLOUNT, MARY .... Marshalltown
BOND, D. K .... Rockwell City
BOODY, DR. GEORGE .... Independence
BOUSKA, F. W .... Dairy Commission, Des Moines
BRAINARD, J. M .... Boone
BROWN, EUGENE .... Mason City
BROWN, J. C .... State College, Ames
BROWNLIE, I. C .... Ames
CAMERON, J. E .... Cedar Rapids
CARTER, CHARLES .... Corydon
CRAWFORD, DR. G. E .... Cedar Rapids
DEYOE, A. M .... Britt
ECKLES, C. H .... State College, Ames
ELLIS, SARAH .... State College, Ames
ERWIN, A. T .... State College, Ames
FINCH, G. E .... West Union
FORD, L. H .... Webster City
GIFFORD, E. H .... Oskaloosa
GOW, J. E .... State University, Iowa City
GRAY, C. E .... Wyoming
GREENE, WESLEY .... Secretary of the Horticultural Society, Des Moines

GRETTENBURG, H. N .... Marshalltown
HERSEY, S. F .... State Normal, Cedar Falls
HESS, ALICE .... State College, Ames
HILL, DR. GERSHOM H .... Independence
HINKLE, HON. G. W .... Harvard
HODSON, E. R .... Department of Agriculture, Washington, D. C.
JOHNSON, F. W .... Des Moines
LITTLE, E. E. .... State College, Ames
LIVINGSTON, DR. H .... Hopkinton
MAIN, J. H. T .... Iowa College, Grinnell
MILLER, A. A. .... Davenport
MUELLER, HERMAN .... Winterset
MYERS, P. C. .... Iowa City
OSBORN, B. F. .... Rippey
POWERS, H. E. .... Columbus Junction
RADEBAUGH, J. W. .... Simpson College, Indianola
ROLFS, J. A .... State College, Ames
SAMPLE, A. F. .... Lebanon
SAVAGE, J. E .... Western College, Toledo
SIMPSON, HOWARD .... Columbus Junction
SKINNER, A. S .... Upper Iowa University, Fayette
SMITH, DR. G. L. .... Shenandoah
STEWART, HELEN W .... Des Moines
STULL, W. N. .... Iowa College, Grinnell
VANDIVERT, HARRIET .... Witchita, Kansas
WALTERS, G W .... Cedar Falls
WEAVER, C. B .... Denver, Colorado
WILDER, F. A .... Geological Survey, Des Moines
WILLIAMS, I. A .... State College, Ames
YOUNG, LEWIS E .... State College, Ames

CORRESPONDING MEMBERS.

Arthur, J. C. .... Purdue University, Lafayette, Indiana
BAIN, H. F. .... Idaho Springs, Colorado
BALL C. R. .... Department of Agriculture, Washington, D. C.
BALL, E. D. .... Agricultural College, Ft. Collins, Colorado
BARBOUR, E. H. .... State University, Lincoln, Nebraska
BARTSCH, PAUL .... Smithsonian Institution, Washington, D. C.
BEACH, S. A .... Geneva, New York
BEACH, ALICE M .... University of Illinois, Urbana, Illinois
BESSEY, C. E .... State University, Lincoln, Nebraska
BRUNER, H. L .... Irvington, Indiana
CALL, R. E. .... 283 Winthrop St., Brooklyn, New York
CARVER, G W .... Tuskegee, Alabama
COBURN, GERTRUDE .... Kansas City, Kansas
COLTON, G. H .... Virginia City, Montana
CONRAD A. H .... 1621 Briar Place, Chicago
CRAIG, JOHN .... Cornell University, Ithaca, New York
DREW, GILMAN C .... State College, Orono, Maine
FRANKLIN, W. S. .... Lehigh Univ., South Bethlehem, Pennsylvania

GILLETTE, C. P.	Agricultural College, Ft. Collins, Colorado
GOSSARD, H. A.	Lake City, Florida
HALL, T. P.	Kansas City University, Kansas City, Missouri
HALSTED, B. D.	New Brunswick, New Jersey
HANSEN, N. E.	Brookings, South Dakota
HANSEN, MRS. N. E.	Brookings, South Dakota
HAWORTH, ERASMUS	State University Lawrence, Kansas
HEILEMAN, W. H.	Pullman, Washington
HITCHCOCK, A. S.	Agricultural College, Manhattan, Kansas
HUME, H. H.	Lake City Florida
MALLY, F. W.	Hulen, Texas
MCGEE, W. J.	Bureau of Ethnology, Washington, D. C.
MEEK, S. E.	Field Columbian Museum, Chicago, Illinois
MILLS, S. J.	Denver Colorado
NEWELL, WILMON	Ohio Experiment Station, Wooster, Ohio
OSBORN, HERBERT	State University, Columbus, Ohio
OWENS, ELIZA	Bozeman, Montana
PATRICK, G. E.	Department of Agriculture, Washington, D. C.
READ, C. D.	Weather Bureau, Vicksburg, Mississippi
SIRRINE, F. A.	Jamaica, New York
SIRRINE, Emma	Dysart, Iowa
SPENCER, A. C.	U. S. Geological Survey, Washington, D. C
TODD, J. E.	State University, Vermillion, South Dakota
TRELEASE, DR. WILLIAM	St. Louis, Missouri
UDDEN, J. A.	Rock Island, Illinois
Winslow, Arthur	Kansas City, Missouri
Youtz, L. A.	New York City, New York

PROCEEDINGS

OF THE

FIFTEENTH ANNUAL SESSION

OF THE

IOWA ACADEMY OF SCIENCES

The fifteenth annual session of the Iowa Academy of Sciences was held in the rooms of the Iowa Geological Survey at the capitol building in Des Moines, December 26th and 27th, 1900 In the business sessions the following matters of general interest were passed upon:

REPORT OF THE SECRETARY.

To the Members of the Iowa Academy of Sciences:

During the current year our membership list has been increased by the addition of six fellows, seventeen associate members and two corresponding members; one by special election, Prof R. D. Salisbury, of the University of Chicago, and one by transfer, Mr. Wilmon Newell of the Ohio experiment station, The names of two fellows and one associate member were dropped from the academy roll on account of delinquent dues. The revised roster now shows fifty-six fellows, fifty-three associate members and forty-five corresponding members in good standing I am persuaded that there are many names in the list of associates that should be transferred to the fellowship list, and I would respectfully recommend that the committee on membership carefully canvass the list of associate members as it now stands, with a view to promoting to fellows, those who have served their apprenticeship. Several of our fellows and members have removed from the state and their names should be considered with a view to their transferrence to the corresponding membership list.

Volume VII of the Proceedings, containing the papers presented at the fourteenth annual session has finally made its way through the hands of the printer and binder and its distribution to those entitled to it is approaching completion.

Our exchange list has been extended by the addition of the "Northern Indiana Historical Society," of South Bend, Indiana; "Ohio State Archaeological and Historical Society," of Columbus, Ohio; and "Wyoming Historical and Geological Society," of Wilkesbarre, Penn. The exchanges of the academy are now being cared for satisfactorily by the state librarian.

A number of inquiries have been received from members and fellows involving a knowledge of our constitution and by-laws, especially those sections which have been recently amended. I would recommend that a committee be appointed or elected to codify and prepare for printing the constitution and by-laws of the Academy and that the same be printed in the next volume of the proceedings. Respectfully submitted.

S. W. BEYER.
Secretary.

REPORT OF THE TREASURER FOR 1900

RECEIPTS:

H. F. Bain, balance	$ 57.20
For Membership	44.06
Back Dues	3.00
Fellowship Dues	6.00
Sale of Reports	3.50
	$113.76

DISBURSEMENTS:

Rent of Hall	$ 25.00
Preparation for Lecture	2.50
Printing Programs, etc	7.75
Expenses, Prof. Pammel	2.72
Receipt Books	1.25
S. W. Beyer, Book and Stamps	2.10
Stamps, $1.75; express, $2.08	3.83
Miss Kelsy, stenographer on work for secretary	2.00
	$ 47.15
Balance	$ 66.61

Very respectfully,

J. B. WEEMS, *Treasurer.*

At a meeting of the executive council of the academy the following fellows and members were elected:

FELLOWS.

W. C. Alden, assistant geologist, U. S. geological survey, Mount Vernon, Iowa; Alfred N. Cook, professor of chemistry, Morningside college, Sioux City, Iowa; F. W. Faurot, instructor in botany, Iowa State college, Ames, Iowa; W. D. Hunter, assistant entomologist, Iowa experiment station, Ames, Iowa; Miss Charlotte M. King, artist, Iowa State college, Ames, Iowa; Louis A. Klein, professor of theory and practice of medicine and sanitary science, Iowa State college, Ames, Iowa; Nicholas Knight, professor of chemistry, Cornell college, Mount Vernon, Iowa; John H. McNeill, professor of anatomy and the principles and practice of surgery, State College, Ames, Iowa; A. Estella Paddock, instructor in botany, Iowa State college, Ames, Iowa; John J. Repp, professor of pathology and therapeutics, Iowa State college, Ames, Iowa; L. R. Walker, instructor in zoology, Iowa State college, Ames, Iowa.

ASSOCIATE MEMBERS.

Dr. Bert H. Bailey and Prof. Louis Begeman, Cedar Falls; Mary Blount, Marshalltown; Dr. George Boody, Independence; E. Vane Brumbaugh, Cedar Falls; Sarah Ellis, Ames; A. T. Erwin, Ames; L. H. Ford, Webster City; C. E. Gray, Wyoming; S. F. Hersey, Cedar Falls; Hon. G. W. Hinkle, Harvard; F. A. Lacey, Des Moines; H. E. Powers, Columbus Junction; Howard Simpson, Columbus Junction; Dr. G. L. Smith, Shenandoah; W. N. Stull, Grinnell; Lewis E. Young, Ames.

CORRESPONDING MEMBERS.

Dr. William Trelease, director of the Missouri botanical garden, St. Louis, Missouri; J. A. Udden, professor of geology in Augustana college, Rock Island, Illinois.

The nominating committee reported the following officers for the ensuing year:

President.—A. A. Veblen.
First Vice-President.—H. E. Summers.
Second Vice-President.—J. L. Tilton.
Secretary.—S. W. Beyer.
Treasurer.—J. B. Weems.
Elective Members of the Executive Committee.—M. F. Arey, H. M. Kelly, C. O. Bates.

In accordance with the recommendation in the secretary's report, a committee was appointed to prepare the constitution and by-laws of the academy for publication. The chair named Beyer, Veblen and Arey.

At the literary session topics of prime importance came up for discussion and lead to the appointment of the following committee:

A committee of three to draw up resolutions endorsing the movement toward forest preserves, and memorialize congress to establish a forest preserve in the upper Mississippi valley. On this committee were appointed L. H. Pammel, Thos. H. McBride and H. A. Mueller.

RESOLUTIONS OF THE ACADEMY OF SCIENCE

WITH REFERENCE TO THE NATIONAL PARK AND FOREST RESERVE AT THE HEADWATERS OF THE MISSISSIPPI, AND THE GENERAL POLICY OF THE UNITED STATES WITH REFERENCE TO FOREST RESERVES.

In view of the fact that there is now a petition before Congress from the people of the state of Minnesota asking the setting aside of certain tracts of

timber land included in the Leech Lake Indian reservation in Minnesota, except such lands as have been allotted to the Indians in severalty, as a National Park and Forest Reserve, for the purpose of preserving the timber and conserving the water supply of the Mississippi river, and in view of the fact that other tracts of timber lands in the northern part of Minnesota, Wisconsin and other states and territories in the Union from which the timber has been removed, which have reverted back to the government, should be set aside for forestry purposes that they may again be covered with forest growth to supply coming generations; therefore,

Resolved, That the Iowa Academy of Sciences in session hereby petition Congress, first, To segregate for park and forestry purposes, the said tract of land at the headwaters of the Mississippi and such other lands as Congress may have control over in the states of Minnesota and Wisconsin and in other states, especially the Rocky Mountain and Sierra regions, to the end that not only the timber supply of said states may be partially saved, but for holding the moisture in said regions, and also for the preservation of our wild game; second, We also favor the purchase of the land for a proposed Southern Appalachian National Park.

Resolved, third, That the government withold from the market public lands covered with timber, that the mature timber on the same be sold under the supervision of a technically trained forester; fourth, That we urge upon our delegates in Congress the feasibility of concentrating the forestry work; and urge that the government establish a rational system of forestry, especially with reference to our forest reserves; and fifth, That the supervision of these forest reserves be placed in charge of trained foresters, all under one responsible head, preferably the United States Department of Agriculture, to the end that a more rational system of forestry may be introduced in this country.

L. H. Pammel,
T. H. Macbride,
H. A. Mueller,
Committee.

A committee was appointed to memorialize the next legislature and draft a bill for the regulation of foods; and, if desirable, to co-operate with committees from other organizations created for the same purpose. Also to take up the investigation of food products and report progress to the Academy:

The chair appointed:

J. B. Weems,
C. O. Bates,
W. S. Hendrixson,
Nicholas Knight,
Maurice Ricker.

Professor Veblen pointed out the desirability of a National Standardizing Bureau, and by order of the

Academy the following letter was addressed to each member of the Iowa delegation in Congress:

DES MOINES, IOWA, Jan. 2, 1901.

DEAR SIR:

I beg leave to call your attention to the following resolutions adopted unanimously by the Iowa Academy of Sciences, at a meeting of the Council on December 27, 1900:

"*Resolved*, That the Iowa Academy of Sciences approves the present movement toward the expansion of the Office of Standard Weights and Measures into a National Standardizing Bureau; and

"*Resolved*, further, that the Academy earnestly urges upon the Senators and members of the House of Representatives from the State of Iowa the desirability and importance of early action on the bill (H. R. 11350) now before congress, by the adoption of which, such a bureau would be established."

S. W. BEYER,
Secretary Iowa Academy of Sciences.

A. A. VEBLEN,
H. W. NORRIS,
Committee.

At the literary session the following papers were presented:

"The Harriman Alaska Expedition," illustrated by a series of excellent lantern slides.—Dr. Wm. Trelease, director of the Missouri botanical garden in St. Louis, Missouri.

The Presidential address, "The Social Service of Science."—W. H. Norton.

1. Note on the time of sexual maturity of some Iowa Unios.—Harry M. Kelly.

2. The Morphology and Function of the Amphibian Ear; a combination of chromic acid, acetic acid and formalin as a fixative in animal tissues.—H. W. Norris.

3. Generic synopsis of the Nearctic Scutelleridæ and Cydnidæ.—H. E. Summers.

4. Notes on the development of Astragalus caryocarpus.—F. W. Faurot. (Introduced by L. H. Pammel.)

5. The Cupuliferæ and Juglandaceæ.—T. J. Fitzpatrick.

6. Methods of keeping living plant material in the Laboratory.—Haven Metcalf.

7. Shrubs and forest trees of Madison county.—H. A. Mueller.

8. Notes on the Bacteriological analysis of water; the native thistles of Iowa.—L. H. Pammel.

9. Bacteriological observations on the Iowa State College sewage.—L. R. Walker.

10. Some observations on the Flora of Southern Alabama, Mississippi and Louisiana; Photographic experience along the Gulf Coast.—F. M. Witter.

11. A study of a terrace formation on the Turkey River, near Eldorado, Iowa.—G. E. Finch.

12. The equivalent of the Hiatus at the base of our coal measures and the Arkansas series, a new Terrane of the Western Carboniferous; Old

volcanic necks of Piatiagorsk; and names of coals west of the Mississippi.—Chas. R. Keyes.

13. Diphenyl Ethers.—Alfred N. Cook. (Introduced by S. W. Beyer.)

14. Some recent analyses of Iowa building stone; also of Iowa potable waters.—Nicholas Knight.

15. A study of Reversible Re-actions.—W. N. Stull. (Introduced by W. S. Hendrixson.)

16. A study of contaminated water supply; the influence of chlorine as chlorides in the determination of oxygen consumption in water analysis.—J. B. Weems and J. C. Brown.

17. A study of some cotton seed oils.—J. B. Weems and H. N. Grettenberg.

18. An expedient for maintaining constant temperature through the process of salt glazing clay wares.—I. A. Williams.

19. Preliminary report on the flowering plants of Adair county.—James E. Gow.

20. Pure Food legislation, discussion opened by C. O. Bates.

21. A comparison of media for counting bacteria in milk; a method for isolating and counting gas producing bacteria in milk.—C. H. Eckles.

22. A drift exposure in Tama county.—T. E. Savage.

23. The loess and modern molluscan faunas of Iowa City and vicinity; the loess and associated deposits on the state farm at Lincoln, Nebraska; a supplementary list of Lyon county plants,—B. Shimek.

24. A National Standardizing Bureau, discussion opened by A. A. Veblen.

25. A review of the Tettigonidæ of North America north of Mexico.—E. D. Ball.

PRESIDENTIAL ADDRESS.

THE SOCIAL SERVICE OF SCIENCE.

BY WILLIAM HARMON NORTON.

The extent to which society may may be considered as an organism is still, I understand, a matter of controversy with sociologists. But without awaiting its adjudication, we may surely make use of a simile as ancient as that of the Apostle who spoke of individual Christians as members of one body, or as that of the wise old Roman, who taught the mutinous plebs the parable of the body politic, all of whose members were nourished by the well-fed patrician belly, and consider together this evening the social function of science in the body social.

It may at least supply a convenient means of classifying the various services of science to the commonweal, if we consider it not so much, perhaps, a distinct corporal member as a growth force, ever accelerating the evolution of society, providing it with means of defense, increasing its muscular energy, and perfecting its systems of circulation and communication. And if to these services we add the reaction upon the social mind of the physical environment which science has provided, and the direct influence of scientific truth, we shall then have sketched at least the main functions of science in social evolution.

Among the first services to society which our biologic analogues suggest is that of defense. Under the growth force of science the body social has accomplished an evolution similar to that which brought the vertebrates, assumed to have been at first naked and defenseless, to the stage of the armored fishes of the Devonian, and which in the Tertiary changed tooth to tusk, nail to claw, and frontal boss to horn and antler.

Prescientific society was destroyed largely because it had attained no adequate means of defense. It is safe to say that had the Roman legionaries been equipped with Maxims and Mausers, the episode of the Hun and Vandal invasions of Southern Europe would have been indefinitely postponed.

Modern society, which science has armed with the most terrible of death-dealing weapons, whose explosives are brought from the laboratory of the chemist, whose immense guns are fired at ranges which require the rotation of the earth to be taken into account, and with a precision which considers the difference in density of the air at the top and at the bottom of the bore, whose war ships are armored with the latest discoveries of metallurgy, their turrets turned and their guns loaded and trained by the electric current, and their evolutions directed by invisible vibrations of ether,—surely a society thus armed has nothing to fear from any barbarian peril, be it yellow or be it black.

Civilization is safeguarded by science, not only from the irruption of savage hordes, but also from the invasion of disease, from such epidemics as that which in the middle of the 14th century swept away twenty-five millions of people in Europe, and more than half the population of England. Today when the plague appears in San Francisco or in London, it excites no more alarm than Gibraltar would feel at the assault of Spaniard or Moor. By the simple remedy of vaccination, science has saved in each generation of the century more lives, it is said, than were lost in all the wars of Napoleon. Among civilized nations within the last five centuries the death-rate has been so lowered that the average duration of human life has nearly doubled. Medicine no longer attacks disease with charm, exorcism and nostrum; she obtains her weapons from the armory of science. From chemistry she brings a pure materia medica, new compounds, new processes, new methods of diagnosis, and anæsthetics which have made surgery painless. From physics she obtains the appliances of electro-therapeutics, a delicate cautery, and the Rœnt-

gen ray, used by physicians in almost every town of size in Iowa within less than half a decade of its discovery.

The debt of the healing art to the sciences of the biologic group is so vast that I will select but one, bacteriology, for illustration. It is to no lucky chance that the discovery is due of man's most subtle and deadly foes, the bacteria. The work of Pasteur, the pioneer, and of his illustrious followers, is marked by the most thorough and painstaking investigation, and the most searching and rigid tests. It is by the application of the scientific method that the enemy has been unmasked, his ambuscades and chosen places for assault discovered, and rational methods for his destruction demonstrated. It is men of science who have organized the victory of medicine today over diphtheria, rabies, and the plague, over the venom of the snake and all the diseases to which serum therapathy is successfnlly applied. And where the bacteriologist cannot as yet supply a specific for disease, he can often point the way to its prevention. When the access to the human system of the germs of typhoid and cholera by drinking water is demonstrated, Hamburg builds its filter beds at a cost of $2,280,000, and Chicago expends $33,000,000 upon the drainage canal. And so with the great white plague, tubercular consumption. Science has proved the lurking-places of the contagion in the sputum, and its carriage in the air we breathe, and reinforced by the high moral sense of our people, she is fast making it as impossible for the consumptive to spit on the pavement unhindered as for the small pox patient to walk unarrested down our streets.

And who can estimate the number of lives now saved in each generation by aseptic surgery? So long as putrefaction was held, as by Liebig, to be due to the action of the oxygen of the air, no remedy for it could be suggested. But when once its bacterial origin was proven, the step was inevitable to those precautions which have rendered safe and successful the marvellous operations of modern surgery.

Micro-biology extends her aegis also over the herds and crops of man. She destroys the insect enemies of our grain fields and protects vine and fruit tree from blight and mildew. She saves the silk worms of Europe from the plague which threatened their destruction, and the flocks and herds of America from some of their most destructive diseases. In twelve years the application of Pasteur's inoculations saved France seven million francs in the item of anthrax, and reduced the mortality of hog erysipelas from 20 per cent to 1.45 per cent.

Thus science performs a service to society incalculable in its value. It defends it from foes, both within and without the gates. It prolongs life, assuages pain, lessens disease, and makes death a euthanasy. So notable have been its victories during the century that we may almost prophesy the speedy coming of the time when the only deadly bacillus remaining will be that as yet undescribed species of bacillus senectutis, or at least when only sufficient of disease will be left on earth to provide for the speedy and a beneficent extirpation of the unfit.

Viewing organic evolution from the angle of the physicist and considering the animal body simply as a machine for the transformation of potential into kinetic energy, the secular process sums itself up in the production of better and better machines. From the fish of the early Paleozoic on to the amphibian of the Carboniferous, the reptile of the Mesozoic, and the mammals of the Tertiary and of the present, we have a series of higher and higher organisms, each capable of doing more work and better work than its predecessors.

It is possible to construe social evolution in the same terms. Primitive society was weak. The energy at its disposal was that only of the human body, the beast of burden, and to a limited extent, of wind, water and flame. So feeble was the ancient state in what may be termed its musculature, so little could it utilize the forces of nature, that it may be compared with a stage of organic evolution preceding that of the vertebrata, that, let us say, of the

turbellarian worm, "whose arrangement of muscles," biologists tell us, "is far from economical or effective."

J. M. Tylor, Whence and Whither of Man, Morse Lectures, 1895, N. Y., 1896, p. 47. In comparison, modern society may be likened to one of the higher mammalia, such as the tiger or the elephant, which cannot only take up from nature the maximum of energy, but can also apply it in varied movements and a highly complicated conduct.

Consider the vast stores of energy which society has to-day at its disposal. The steam power of the United States alone equals the day labor of one hundred million men. Behind each man, woman and child of the nation stands more than an automaton of steel with the strength of a man, but with manifold his capacity for productive labor. In carding, for example, fingers of steel do in half an hour what the unaided workman of a century ago could not have accomplished in less than eight months. In machinery society finds a tireless hand capable of performing the mightiest and the most delicate of tasks with equal ease. It strikes with the steam hammer a blow of 2,000 tons, and it rules the Rowland grating with its 48,000 parallel lines to the inch.

Consider also the new induement of energy which science has bestowed upon society in the gift of electricity, a power capable of the swiftest and most ready transmission, of infinite subdivision, and of the greatest known intensity of concentration. And how varied is its functioning! In mine and quarry it picks and drills and fires the blast. At the wharf it lifts and loads and carries. In the factory it forges, casts, welds and rivets. In the home it shines in the most healthful light yet made by man. In electrolysis it produces a hundred substances of value, such as the caustic alkalies, bleaching powder, chloroform, the chlorates, and aluminum, the metal perhaps to give name to the new century. From the refuse of the mine it extracts millions of dollars worth of the precious metals. It surfaces steel and iron with zinc, nickel or copper, with silver or gold, and copies infallibly the engraved plate of the map and the type set page. In the electric furnace it

[illegible]

[illegible] the printing press and the compass [illegible] protected from [illegible] of the ship. Invention is [illegible] as has been well said, science must [illegible] before it can be applied. Between the scientific investigator, the discoverer of principles, and the inventor who applies them, there need be no jealousy. If the latter has the popular fame and the financial reward of the present, it is often to the former that the future belongs, and in any event, in the words of the generous Schley at Santiago, "there is glory enough for all." And, after all, why should the name of science be refused to that vast body of knowledge, classified and tested, which is in daily use in the laboratories of the industries of the world.

But to science, even in its most restricted sense, the debt of society is incalculable. It has evoked those good genii, steam and electricity. Watt was led to the invention of the steam engine, not by a boy's glance at his mother's tea kettle, but through the discovery by Black of latent heat, and after two years of profound study of such

abstruse problems as the specific volume of steam and its law of tension under varying temperatures. And the improvements in the steam engine, which since the fifties have more than doubled the speed of the piston, while saving at least one fourth of the fuel, have been made under the guidance of Joule and the mechanical theory of heat. In the matter of the advantage of super-heated steam and high pressure, theory still seems to outrun practice.

In electricity the mere mechanician can take no important step beyond the scientific discoverer. How happy was the thought which designated the various units of electricity by the illustrous names of the masters of research,—volt, in honor of the professor in the University of Pavia who one hundred years ago gave the world in his crown of cups its first effective reservoir of the new power; ampere, the name of the professor of physics in the College of France, founder of the science of electro dynamics; ohm, in memory of the professor of experimental physics in the University of Munich, discoverer of the law of the strength of the electric current; and farad, in honor of the greatest of them all, Michael Farady, professor of Chemtry in the Institution of England, the prince of experimenters, whose researches, resulting in the dynamo, connected up the industries of the world to the first economical source of electrical energy.

Illustrations of the dependence of industry on pure science are everywhere at hand. When as an amateur in photography, I take up a package of eikonogen or hydroquinon, the label with the name of one of the great aniline factories of Germany, at Elberfield, Mannheim, or Berlin, reminds me of the debt of the *Farbenfabriken* to men of research. To the chemist is not only due the discovery of developers, of such bye products as antipyrine, cocaine, saccharine and vanilline,—it was he who, in the black amorphous coal tar, the former refuse of the gas works, first found there brilliant crystalline dyes which have so largely replaced all other colors in the dye vats of the world. So far as I am aware, no monument has been

raised to these discoverers, to Hoffman, Graebe and Liebermann. In a more telling way industry acknowledges her debt to pure science when a great aniline factory such as that at Elberfield employs sixty professional chemists and turns the attention of twenty-six of them to pure research in discovery of new compounds.

Science has thus given society command of energies of the highest efficiency. It has made the comforts of life common and cheap; it has lifted from the shoulders of labor its heaviest burdens and set free for higher social services all who are capable of their performance. It is the undiminishing fountain whence flows the world's material wealth.

The evolution of the circulatory system in the body physiologic suggests a similar development in the body social. The process which during the geologic ages slowly changed the primitive gasto-vascular cavity to the perfected circulation of the higher animals to-day, which evolved from a simple pulsating tube the powerful four-chambered heart, may at least serve as a simile to the evolution of the distributory or transportative system of modern society. So obvious is the analogy that the arteries of commerce is a phrase of common parlance. But for our purpose it will not be necessary to carry the likeness into details, to discriminate, as some ingenious sociologists have done, the various organs, such as the capillaries, or to liken the red corpuscles of the blood to the golden discs of the circulating medium. Let it suffice to show that by the application of the discoveries of science society has obtained a system incomparably rapid and effective for the distribution of power, of food, and of all the products of labor.

The world is enmeshed by lines of railway and steamship. They carry the products of our Iowa farms to west Europe, to South Africa and to China. To our dinner tables they bring in return linen from Ireland, porcelain from France, cutlery from Old England and silverware from New England, meats and fruits from states as distant as Texas, California and Florida, spices from the East Indias,

and beverages from Japan and Java and the valley of the Amazon. In the United States alone there are now in operation nearly 200,000 miles of railway, carrying yearly one billion tons of freight and 550 millions of passengers.

The carriage of power is accomplished at present almost wholly by the transportation of fuel. The value of this service may be seen by contrast with some railroadless country such as China, where according to Colquhon, coal selling at the mine at fifteen cents per ton, cost as many dollars ten miles away. But the future doubtless has in store the distribution of power as an article of merchandise. The possibility of long distance transmission of electricity has already been demonstrated at Niagara, and the time may be near when in our cities power from coal field or waterfall may be purchased for use in factory and home as readily as water or gas today.

What has already been said of the debt of industry to science in the development of its motive powers applies here equally in transportation. Permit a single illustration further of the value of pure science in the evolution of the circulatory system. Every engineer is aware of the large contribution which the steel rail has made to the success of the railway. Durable, strong and cheap, it has displaced on all our railways the weak and short-lived rail of iron. It has made possible heavier trains and higher speeds. Together with other factors it has so cheapened traction that, according to Professor J. J. Stevenson, the coal of West Virginia is now sold at New York City for less than one-fourth the railway freight charges of a quarter of a century ago. But it is no belittlement of the laurels of Sir Henry Bessemer, the inventor who has made all this possible, to point to the fact that the success of his process which, by ushering out the Age of Iron and ushering in the Age of Steel, has revolutionized industry and touched every home with its beneficence, is due not only to his use of a great body of facts in the chemistry of the metals, but in especial to the utilization by Mushet of the facts regarding the influence of manganese and its relation to carbon,—facts ascertained in the laboratories of science

and left on record to await their use by invention at the proper time.

The mobility in the social organism so largely due to science has had far-reaching effects. It stimulates production to the utmost. It opens the markets of the world to the products of every worker. Labor has itself become mobile, and in the factory raw material from distant lands meet operatives from across the seas. It is the cause of vast immigrations such as that which has brought to the United States more than nineteen and a quarter million people since the opening of steamship routes across the Atlantic. It makes impossible in civilized lands such famines as that which in 1878 in two of the northern provinces of China destroyed more than nine million men. It opens to the occupation of a single homogeneous civilized commonwealth such vast areas as the Mississippi Valley. To any such it would be as fatal to stop the social circulation made possible by science, as in a limb of the body to ligate the main artery. Dense population can indeed exist wherever food can be raised in abundance, as on the river plains of China, but without the modes of distribution introduced by the science of the nineteenth century, they can neither be unified into a homogeneous community nor can they be lifted to the levels of modern civilization.

By its systems of circulation which break down all barriers, science has brought about the supreme crisis in social and political evolution. Like the epeirogenic movements which mark the crises in geologic history, which united continents and precipitated alien upon indigenous fauna, so science has brought civilization and barbarism the world over in all their stages to meet in a life and death struggle, and offers to the fittest the prize of a world encircling empire.

The fact that in order to operate the railway it is necessary to send signals at greater speeds than those of moving trains, suggests another service of science,—the highest material service which it renders the commonweal. In the telegraph and telephone a system is supplied for the

almost instantaneous transmission of motor and sensory impulses throughout the body politic. In general terms we may compare the growth of the communicating system of society to the development of the nervous system in the history of animal life, where the scattered central cells of Nature's first sketch of such a system are later gathered into ganglia and ganglia massed into a brain connected with every part of the body by ramifying nerve filaments. Of all social organs this seems the most retarded in its evolution. In primitive society it is only the smallest groups, such as the family and the village community, which have a facility of communication comparable to that of the lowest of the metazoa. In the larger groups of the tribe and nation we find a stage more advanced than that of the hydra only after science has made possible the railway post and the telegraph and telephone.

That Morse is the inventor of the electric telegraph is a statement more veracious than that of the Vermont farmer who said that everybody knew that Edison invented electricity. But the name of the inventor of every great tool of society is legion. Morse set the key stone of the arch, but its voussoirs had been built by investigators unknown to popular fame in many lands, and even the keystone was almost placed in the hands of the distinguished inventor by the great physicist, Henry Oersted, who in 1819 deflected the magnetic compass by a voltaic current in a neighboring wire; Arago, whose experiments with iron filings proved that this current would generate magnetism; Ampere, with his suggestion of the possibility of signalling at a distance by the deflection of needles; Sweiger, who took up Oersted's experiment, and discovered that the deflecting force of the current was increased when the wire was coiled about the magnet; Sturgeon, who making use of Arago's discovery, replaced Sweiger's magnetic needle with soft iron and thus constructed the first temporary or soft magnet; Henry, who strengthened the electro-magnet, and used it with over a mile of wire to give signals by tapping a bell; Gauss and Weber, who strung their wires at Goettingen and read the deflections of the

galvanometer, all of these men, devoted solely to knowledge for knowledge sake, are sharers with Morse and Vail in the glory of the invention of the telegraph.

And so with wireless telegraphy. In Marconi's hand this invention blazes with a sudden brilliance which attracts the attention of the world, but the torch has been conveyed to him along the line of many runners in the torch-race of scientific discovery. From Clerk Maxwell who showed the analogy between electricity and light, from Hertz, with his demonstration of electro-magnetic waves, from Onesti, of Fermo, and Branly, of Paris, and Lodge, of London, whose researches produced in the coherer an instrument capable of seeing such waves, from these and others the torch was passed on to the great inventor whose improvements in apparatus made effective the discoveries of science.

In the telephone at least four scientific principles are involved—the voltaic current, the interaction of magnetism and electricity, the temporary magnet and the microphonic action of carbon. Through this marvelous invention each master in electrical science from the time of Galvani, who has aided in the elucidation of these principles, though dead, yet speaketh.

Thus we may fairly claim that to science in large measure is due the plexus of post, telegraph and telephone, by which intelligence is flashed throughout the body social even more swiftly than along the nerves of the body physiologic. And how incalculable is the service which science thus renders. Consider the extent of the channels of communication. The domestic mail service of the United States requires each year twenty-one million miles of travel. Sixty-four years ago the first commercial telegraph was built with a length of forty miles. At the close of the century there are not less than one million miles of telegraph in the United States, over which duplex and multiplex messages are carried at the same time, and the rate of transmission has risen to six thouand signals per minute. One hundred and seventy thousand miles of submarine cables moor coasts, islands and continents together.

Over one million miles of telephonic wires have already been strung in our own country. Boston, a typical city, measures its electric nerves at a total of one hundred and seventy million feet, and the radius of audible speech from it reached a year since, according to Iles, to Duluth, Omaha, Kansas City, Little Rock and Montgomery.

Note the saving of time and energy thus accomplished. Without leaving his desk the manager of a business is in instant communication with all his employes, and with the business enterprises in his own and other cities. The captains of industry are thus able to command armies of a size unthought of a few decades since. So accurate and instant are the new motor and sensory nerves that the oil refineries, the copper mines, the steel mills, almost any industry that may be mentioned, can be regimented under one control, and an industrial revolution is accomplishing before our eyes.

The electric wire, with the fast mail and the newspaper, flash the news of the world throughout all civilized countries. When our army attacks Santiago or marches on Pekin, the public becomes impatient of even the interval between the morning and the afternoon paper. On the night of a national election the American public listens to the count of votes in every city and in every state. The new discovery of science, the new mechanical process, the new remedy for disease, are communicated without delay to the entire world. In commerce local prices seek the level of the world market, and the entire distributing system is as effectively controlled as are the capillaries of the animal body by the clutches of the nerves. In a theatre vast as the whole earth we look down on the stage, upon which is played the never ending drama of current history.

In a still larger sphere the new organ of communication has a reflex on civilization. It makes possible self-governing communities, stretching from the Atlantic to the Pacific. Bringing Washington face to face with London, Paris and Berlin, and the other capitals of Europe, it enables the great powers of two continents to arrange without delay a concert of action whose message flashes

'round the planet and is carried into effect at Tientsin and Pekin. In direct contrast, unscientific China outspreads her bulk like some vast insensate vegetal growth. Under attack even at a vital point, she can neither mobilize her armies, nor even disseminate a knowledge of the danger before it is too late. It has been said by Giddings that, "objectively viewed, progress is an increasing intercourse, a multiplication of relationships, an advance in material well-being, a growth of population, and an evolution of rational conduct. Subjectively, it is the expansion of the consciousness of kind."*

In all these respects science has been an accelerating force in the evolution of society. Increasing food supply by means of scientific agriculture, lengthening life by the repression of diseases, and introducing a thousand new means of livelihood, it has made possible the extraordinary recent growth of civilized nations. It permits the population of Europe to more than double since 1800, and enables England, which in the seventeenth century men thought too small for its scanty population, to support in comparative comfort more than 38,000,000 people. It encourages the prophecy of Albert Bushnell Hart, that the Mississippi valley will sooner or later contain a population of 350,000,000.

At the same time science has produced a heterogeneity of structure. The scientific principle discovered to-day flowers to-morrow in invention and produces the seeds of social arts and crafts. To Volta's researches in his villa on Lake Como 5,000,000 men now employed in the many various arts connected with electricity, owe in a measure their livelihood. In promoting the development of the complex organs of society for the handling of energy, for distribution, and for communication, science has constantly been a differentiating force.

By the same means it is accomplishing a more and more complete integration. The separate life of primitive society, the old personal independence, is gone. In the

*Principles of Sciology, New York, 1896, p. 359.

new order all social units and aggregations are interdependent. We are all members of one body. We must not ignore the purely psychic factors of social progress, but these alone could not maintain the new order apart from the physical basis built by science. Were this support withdrawn it would seem that over large areas now occupied by civilization, society must lapse and break into fragments, fast degenerating the state of the villages of the Russian plain, the scattered communities of the southern Appalachians, or even the Pueblos of Arizona.

As we have spoken of the service of science in promoting the physical well being of society, there remain of Professor Gidding's notes of social progress only the evolution of rational conduct and the consciousness of kind. These phenomena are involved in the evolution of the social mind. Here science acts directly, and also by the reflex of the social organism. The organic unity of society is the ground for the expansion of the consciousness of kind. The social ties woven by science help to produce a wider social sympathy. Under the regime of science the barriers of the mark break down everywhere and are transformed into the market, and with their downfall provincialism, indifference and hate of once separated peoples pass away. Science has created, as we have seen, a new physical environment, which reacts constantly on the social mind, awakening from torpor, stimulating to greater activity, demanding a more alert attention, and a precision and swiftness of movement before unknown.

Still more directly is science creating an intellectual milieu whose influence on the social mind is as inescapable as is that of climate on the physical life. The world of our forefathers, how close its confines, how dark and shadowy, how uncertain and untrue, compared with the illimitable sphere which science now fills with her clear light. It is a universe, not a multiverse, the new world which science apperceives. It is a world of law, in which each event has adequate cause; the expression of one immanent energy operating across all widths of space and throughout all lengths of time, without loss or increment, and without

variableness or shadow of turning; an eternal becoming, an evolving order which comprehends the growth and decay alike of solar systems and of the humblest of living creatures. It is of this new world that the two master Victorian poets, inspired by both the scientific and the religious spirit, have written:

> All's law, but all's love.

And,

> One God, one law, one element,
> And one far off divine event
> To which the whole creation moves.

The effect of these new cosmic conceptions of science penetrates every department of learning and every field of life. It revolutionizes society, it rationalizes the social mind. It has swept to the limbo of things that are not the sprites of evil which affrighted our forefathers. In this science has done a work which neither literature, nor art, nor religion, nor ethical culture has proved itself able to accomplish. It was the pious Melancthon, the gentle scholar of the Reformation, who at Heidelberg saw in the falling stars only the paths of deceitful devils, and the mandarin to-day, learned in all the ethical wisdom of Confucius, a classical scholar of the finest literary taste, still bursts his firecrackers at the funeral of a friend that he may frighten away the pestiferous spirits of evil which dog the steps of men through life even to the threshold of the world beyond.

The rationalizing influence of science upon civilization needs no illustration to one versed in the literatures of the prescientific ages, to one who has read Plato's Tinæus or Plutarch's description of the moon. And how preposterous were the theories current but a century since, such as those which saw in fossils the freak of some plastic power in nature or the remains of a catastrophe which swept away in a flood of waters the very foundations of the earth. To-day how rare and how interesting are such survivals of this almost forgotten time as the Atlantis of Ignatius Donnelly!

The theory of evolution perhaps furnishes one of the best examples of the replacement of the untruths of the past by truths discovered by science and of their revolutionary effect. Since the discovery of the proofs of this process, man has come to know himself as never before. He understands at least the meaning of history and rewrites his texts on philology, literature and all social and political institutions. He sees, though as yet dimly, some solution to the ethical problems of sin and evil, and beholds as in a panorama the process of his creation.

It is as yet too soon to see the full effect of these new conceptions upon the social mind. Science has not yet come to its own in education, and the irrational and the unreal is far from being wholly banished from society. But more and more the care of the young is entrusted to science to train, as none other can, to be quick of eye, true of speech and rational in thought, to bring them face to face with reality and to open to their view the widest and most inspiring vistas. Common knowledge is one of the strongest social bonds. We meet and touch in what we know. The time has been when educated men drew together in a common knowledge of phrases written in extinct languages. To-day they find this reapproachment, this consciousness of kind, more and more in a common training in science. In the laboratory they have measured the energy of the falling body and studied its transformation into sound, heat, light, chemism, and electricity; they have tested the ray from the hydrogen atom and found its vibration the same from the flame on the table and in the light of Sirius. They have dissected the tissues of life, and have read in Nature's book the life histories of mountain, river and planet. And thus they have attained to that cosmic conception, overwhelming in its sublimity, which is the best gift of science to man.

The reward which science asks for this service is the wages of going on; she asks for well equipped laboratories, for longer courses of scientific study in schools, for the endowment of scientific instruction and research. Such foundations as the Lawrence Scientific school, the Field

Columbian Museum, and the Smithsonian Institution, are examples of appreciation as yet as rare as munificent. I am not aware of any such in Iowa. When wealth builds the spacious laboratory or endows a chair in science in any college of the commonwealth, it is but rendering to science her own. Each dollar earned by railway, telegraph and telephone, mine and quarry, mill and factory, farm and store, may well pay tithe to science which has made these industries possible. The gratitude for a life saved by the application of science in modern medicine might well be generous. And yet the total gifts to scientific instruction in Iowa, by men of wealth, do not exceed $50,000. I am aware of the state appropriations to the scientific departments in our state institutions, and I should be glad to call them generous. At least they have given Iowa the fame of men whose work in science has achieved national recognition. But these yearly appropriations, were they many times as great, could not supply the place of the great gifts, endowments to be for all time reservoirs of power transmuted constantly into the highest social service. It is the boast of American democracy that by such votive offerings it shows appreciation of education, charity, and scientific research.

As members of a guild of workers in science, let us be thankful for even the humblest place. To discover any fact, however trivial, to add anything however slight, to the sum of human knowledge, this is to shape and dress some stone for the building of science, the home and shelter of the race. Our contribution may go to chink some crevice or at last some master builder may find in it the keystone of an arch or the cap stone of a column, but whatever its place, if our work was well and truly done, it abides, as a permanent service to society.

A REVIEW OF THE TETTIGONIDAÆ OF NORTH AMERICA NORTH OF MEXICO.

BY E. D. BALL.

The present paper has been planned to serve a double purpose. Its first object being to furnish a means of separating and determining the members of this family found in the United States and Canada, together with their varieties and the synonomy as far as it has been worked out. Secondly, to give sufficiently accurate and detailed descriptions in all cases, even where not necessary in the separation of our own forms, so that later workers in the group and those from other parts will be able to discriminate between our species and closely allied forms from other regions, or to recognize our forms when found in other countries.

This is all the more necessary from the fact that this group, which forms a very small part of the Jassid fauna in the United States, becomes the dominant one in tropical regions, especially of the Western Continent. Of the five hundred or more described species the great majority are found in the region between Mexico and Brazil. A number of these species, among which are some of our own forms, extend throughout the whole of this territory.

Taking into account these facts and the addditional one that most of the work on the group so far has been done by European authors, whose material was mainly from tropical regions, and who paid little attention to the isolated descriptions of the American authors, it is little wonder that there is much of synonomy. At the same time American authors have paid little attention to the European work, and a goodly number of the later synonyms are from this side of the water. Mr. Walker, of course, con-

tributed to the confusion. There is much in synonomy yet to be worked out which can only be completed when the species of the different countries have been carefully collected and accurately determined as to specific and varietal limits.

The bibliography of our forms in this group has been so carefully and accurately worked out by Van Duzee in his Catalogue of the Jassoidea that it seemed unnecessary to repeat it here. Under each species is given the reference to the original description and the date, and reference to the descriptions of all synonyms and varieties. In addition to this, references are given to systematic works published since the Van Duzee Catalogue, and references that have been changed from that given in the catalogue, are included, when necessary to make them clear.

There are few characters that seem available for generic use, and consequently, the classification within certain parts of the group is very unsatisfactory. With a limited number of species, such as we possess, one may readily lay down characters that will separate them into well-defined genera, but with a large number the task becomes more difficult.

The author has followed Stal in generic disposition, the main objection to this system being that the genus *Tettigonia* is still burdened with an immense number of quite diverse species. Even in our fauna it contains quite widely separated forms. It will, however, be necessary to study carefully a representative series from tropical regions before any rational and permanent separation can be had. On the other hand, the group represented by *mollipes* is mainly temperate in distribution, we having seven species in our fauna, of which Fowler only records two for Mexico and Central America, and it has been thought best to separate it from *Diedrocephala*.

The adoption of a system of describing by means of varieties, in some cases, was but the choice of evils, it seeming to be almost impossible to define some of the variable forms in any other way. Having adopted that method, it seems preferable to designate them by names rather than

by symbols or letters, as is often done, especially as in the majority of cases these varieties have already received names.

In the prosecution of this work, I have had for study the collection of the Iowa State College and the Van Duzee collection, both very rich in material, through the kindness of Prof. H. E. Summers; the National Museum collection, through the kindness of Dr. L. O. Howard; the Ohio State University collection and the private collection of Prof. Herbert Osborn; a series of Florida forms from Prof. H. A. Gossard; and a fine series of Eastern forms from Mr. Otto Heidemann; the Colorado Agricultural College collection; some typical specimens of Woodworth's species, from the Illinois Laboratory, through Prof. Hart; and numerous smaller series sent in for determination. My own collection includes all but one of the forms enumerated in the paper, as well as a large number of species from Mexico, the West Indies and South America, some two hundred species in all.

This large amount of material has made it possible to more thoroughly investigate and define the ordinary variations of a species and to recognize some hitherto very puzzling forms as only extreme variations in a specific type. Some of these variations were found to run through a considerable number of species, disrtibuted through several genera, often the same variation would be found to occur in a majority of the species of a given locality.

The most striking structural variation commonly met with was the broadening of the head and consequent relative shortening of the vertex noticed in the specimens from the Pacific Coast and Mexican points. This was particularly noticeable in the Western specimens of *T. hieroglyphica* var. *confluens* and in the Mexican specimens, *tripunctata* and *bifida*; specimens of *bifida* from the West Indies were intermediate in this character. Another common variation was the change in the ground color in pronotum and elytra from red to blue and even green, with all possible combinations and variations in these colors. The variations in *T. hieroglyphica* and *O. undata* are striking exam-

ples of this, and it is also found in *T. gothica, occatoria, dohrni, bifida* and *tripunctata*. The darkening up of species in their northern limits is also intensified in this group, and, as usual in the Jassoidea, specimens from the Pacific Coast, especially in the northern part, are considerably larger than those from the Mississippi Valley and farther east. Those from the Rocky Mountains and the adjacent plains are somewhat intermediate, grading off on either hand.

The gentalia are of less importance in this group, as a whole, than in many others, but, as in some species, they are strikingly distinctive and in most cases they furnish good characters in one or both sexes they have been made rather prominent, in striking contrast to the treatment of other authors. The venation of the elyta has been found to be of considerable service in defining groups of species, and in some instances' furnishing specific characters.

The Tettigonidae are at once separated from the rest of the Jassoidea by the ocelli being situated on the disc of the vertex. They are usually divided into two groups, on the general shape of the body, as follows:

General form, cylindrical, usually elongate............Tettigoniina
General form, broadly oval, or flattish, usually compact..Gyponnia

The present paper deals only with the first group, excluding some forms like *Euacanthus* and its allies, which are usually placed here.

SUB-FAMILY TETTIGONIINA.

The following key to the genera while emphasizing the fundamental characters separating the genera, as a whole, makes use of other and minor characters that are of value in separating our forms, but that might be untenable in a larger series:

KEY TO THE GENERA.

A. Antennal sockets usually overhung by a distinct ledge, the anterior extremity of which is deflexed and roundingly truncate. Anterior tibiæ sulcate above or dilated at the extremity. Elytra narrow, not covering lateral margin of abdominal tergum. Head and pronotum usually deflexed.

B. Thorax roundingly six-angular, posterior margin rounding, with a slight medianexcavation. Vertex longitudinally furrowed. Claval veins distant.......*Aulacizes.*

BB. Thorax 4-angular, posterior margin broadly, roundingly emarginate, the anterior and posterior margins nearly parallel. Claval veins often united in the middle or approaching and tied by a cross nervure.

C. Vertex long, triangular, longer than width between eyes side margins nearly straight, face as seen from side nearly straight......*Homalodisca.*

CC. Vertex obtusely rounding, shorter or only equal to width between eyes, face as seen from side roundingly angled ....*Oncometopia.*

AA. Ledge above antennal sockets small, the anterior extremity as seen from above not projecting, included in the curve of the head, Anterior tibiae slender round or triangular, Elytra broad, covering the abdominal tergum. Head and pronotum rarely sloping.

B. Elytra not reticulate veined at the apex, at most with five apical and three anteapical cells. Head not greatly produced.

C. Vertex with the margin rounding obtuse, the front inflated.

D. Antennae setaceous, pronotum not twice as long as scutellum the posterior margin long not strongly emarginate ..*Tettigonia.*

DD. Antennae in the male enlarged at the apex. Pronotum less than twice as long as the scutellum, posterior margin short deeply emarginate.................... *Helochara.*

CC. Vertex flat, the margin sharp or line-marked, distinct, vertex and front forming an acute angle, front broadly transversely convex, not inflated... ....*Diedrocephala.*

BB. Elytra reticulate veined from the apex as far back as the forking of the outer branch of the first sector. Head often produced into a triangle, longer than pronotum.. ....*Draeculacephala.*

GENUS AULACIZES AM. AND SERV.

Head slightly inclined, vertex moderately long, bluntly rounding disc, nearly flat longitudinally, furrowed front gibbous, clypeus as seen from side obtusely angled, a distinct ledge over antennal sockets, pronotum inclined anteriorly long, 6-angular widest at the lateral angles, rounding behind with a slight median emargination as in Tettigonia, anterior tibiæ furrowed on upper side, elytra not concealing lateral margin of abdomen.

But one species of this genus has been found in the United States.

AULACIZES IRRORATA FAB. Plate I Fig. I.

Cicada irrorata, Fab. Ent. Syst. IV., p. 33, 1794.
Cicada nigripennis, Fab. Ent. Cyst. IV., p. 32, 1794.
Aulacizes rufiventris, Walk. Homop. III., p. 796, 1851.
Aulacizes guttata, Uhl. Stan. Nat. His.; Van D. Cat. (Nec. Sign.)
Aulacizes pollinosa, Fowl., Bio. Homop. II., p. 218.; pl. 15, fig. 18

Long cylindrical, testaceous, brown, finely irrorate with pale yellow. Length, 12.5mm.; width, 3mm.

Head with eyes but little wider than pronotum, triangular the apex rounded. Vertex slightly shorter than its basal width, disc sloping, on same plane as pronotum, the surface irregular, a deep median furrow, narrow on posterior half and not quite reaching the margin, broadening out on anterior half until it is bounded by the carinate margin at the apex. Front gibbous, forming a right angle with vertex, clypeus obtusely angled. Pronotum sexangular, rounding in front, the submargin depressed with a few deep pits, disc convex coarsely pitted; humeral margins long, straight, posterior margin rounding with a slight median emargination. Elytra long, parallel margined, opaque not covering the lateral margin of abdomen.

Color; rich leather brown variable in shade, a few irregular blotches on vertex and base of scutellum, a large spot before the apex of the latter, numerous oval spots along the costal margin of elytra and fine irrorations over the pronotum and elytra pale yellow. Vertex and scutellum sometimes suffused with yellowish. Front pale yellow with four black spots in a square above, irregularly black below with a pair of oval yellow spots on clypeus. The yellow band above extends back on sides of thorax to the yellow margin of costa. Abdomen red above, yellowish and fuscous below.

Genitalia; female segment but little larger than penultimate, posterior margin broadly rounding, broadly shallowly notched in the middle; male valve minute, plates concavely triangular apically, convex below, clothed with fine hair, a little longer than ultimate segment.

Specimens are at hand from Pennsylvania, District Columbia, Maryland, South Carolina, Florida, Alabama, Kentucky, Missouri. It occurs from New York to Illinois and Missouri south to Florida and Texas and on into Mexico.

All records for *guttata* within the United States refer to this species. The *guttata* is a very different looking insect scarcely half the size of this species. It belong to the genus *Tettigonia* and has not yet been found north of central Mexico.

VARIETY POLLINOSA FOWL.

Aulacizes pollinosa, Fowl. Bio. Homop. II., p. 218, pl. 13, fig 18, 1899.

Size and structure of typical *irrorata*. Color, orange fulvous, claval areas greenish white, entire upper surface finely irrorate with black.

This is an extreme form of the enlargement of the light spots combined with a change in their color. Specimens are at hand from Florida and Fowler describes it from Mexico.

From Signoret's description there seems to be little doubt but that this is the species that he had in hand and which he said was "common in Brazil." Fowler, however, with "a typical example of Signoret," at hand separated *pollinosa* as distinct from the Brazilian form. If this should prove true, which I doubt, still the name *irrorata* would stand for our form as it was described from Carolina and Walker's rufiventris (which both recognize as a synonym) from Florida.

GENUS ONCOMETOPIA STAL.

Head broader than pronotum; vertex obtuse, rounding, disc convex confused with front, a distinct ledge over antennal sockets; eyes prominent; front gibbous, clypeus scarcely angled. Pronotum short, broadly rounding in front, posterior margin concave, very nearly parallel with the anterior, lateral margins straight, subparallel or slightly narrowed behind. Elytra narrow, margins subparallel, the lateral margins of abdomen exposed. Anterior tibiæ slightly sulcate above.

KEY TO THE SPECIES.

A. Front extending fartherest anteriorly at about the middle, much below the level of vertex and pronotum. Costal area narrow, the cross nervure some distance in front of the fork of first sector. Length 13mm.................. *undata* Fab.

AA. Front retreating from a point on a line with vertex and pronotum. Costal area broad, first sector forked before the first cross nervure. Size, small, 9mm or less........ *lateralis* Fab.

ONCOMETOPIA UNDATA FAB., Plate I, Fig. 2.

Cicada undata, Fab. Ent. Syst. IV., p. 32, 1794.
Cicada orbona, Fab. Ent. Syst. Supp., p. 520, 1798.
Proconia nigricans, Walk. Homop. III., p. 783, 1851.
Proconia clarior, Walk. Homop. III., p. 784, 1851.
Proconia lucerne, Walk. Homo. III., p. 785, 1851.
Proconia marginata, Walk. Homop. III., 785, 1851.
Proconia badia, Walk Homop. III., p. 786, 1851.
Proconia scutellata, Walk. Homop. III., 786, 1851.
Preconia tenebrosa, Walk. Homop. III., p. 787, 1851.
Proconia plagiata, Walk. Homop. III., p. 788, 1851.
Oncometopia undala, Fowl. Bio. Homop. II., p. 231, pl. xiv, figs. 19 and 20.
Oncometopia alpha, Fowl. Bio. Homop. II., p. 232, pl. xiv, fig. 22.

Resembling *A. irrorata* in size and form, but with a much wider head and more prominent eyes. Head and scutellum yellow with black markings. Pronotum and elytra slaty or reddish with blue mottlings. Length, 13mm; width, 3mm.

Head and anterior part of pronotum inclined in same plane. Head broad, eyes prominent. Vertex two-thirds as long as its basal width, roundingly right angled, the apex blunt. Front gibbous, as seen from side rounding, the apex below the middle. Pronotum convex, elevated, one-half wider than long. Elytra long, narrow, claval veins but slightly approaching each other usually with a cross nervure, costal area norrow, scarcely wider than adjacent discal cell, the cross nervure between the sectors some distance before the fork or the first sector.

Color; vertex anterior margin of pronotum and the scutellum rusty orange, an incomplete circle before the middle of the vertex, open in front giving off eight radiating lines, two running back and curving around the ocelli, two running forward and meeting at the apex, the other two pairs equidistant between these, a line along the margin from the eye to the apex, some irregular markings at the base and on anterior margin of pronotum, black. Scutellum with a transverse oval giving off six lines, two to each margin. Pronotum and elytra varying from slaty blue to brown and bright red, sometimes a large pruinose patch on either side just back of the middle of the elytra. Front orange, a black line on middle and a pair of latteral, converging lines which sometimes meet below the apex. Below dirty yellow, abdomen black above, margins yellow.

Genitalia; female segment a little larger than penultimate, the posterior margin divided into three nearly equal rounding lobes, the median one horizontal, the two lateral ones sloping or curved around ovipositor. The horizontal disc parabolic, with a median and often lateral carinæ; male plates about half as wide as the ultimate segment, together equilaterally triangular or slighly elongate.

Specimens are at hand from District of Columbia, Maryland, Virginia, Georgia, North Carolina, Florida, Alabama, Louisiana, Missouri, Texas and Mexico, Central America, Dutch Guiana and Brazil.

It occurs in our territory from New Jersey, Maryland, Michigan, Illinois and Missouri, through the Southern States to Florida and Texas, and on south to Brazil.

The synonomy of this species is very puzzling, and that given above does not represent in full the conclusion reached by the author, but only that part of it that appears to be unquestionable or that comes in our range. After examining a series from South America and compar-

ing them with Central American and Mexican forms it seems nearly certain that *obtusa* Fab. was but a dark variety of *undata*, and as *obtusa* was described first the species would bear that name, while our forms would be the variety. Stal in Hemip, Fabriciana describes *obtusa* as with the head markings of *undata;* these markings are very constant and can be partially traced, except in the darkest forms, and appear to be one of the best distinguishing characters outside of the genitalia. Signoret does not mention these markings nor figure them in *obtusa*, but he places *clarior* Walker from Fla as a synonym, and it had the head markings distinct, as described by Walker. He gives the claval veins as united in *obtusa*, but Stal gives them as like *undata*. Signoret does not describe genitalia under *obtusa*, but under his next species he describes it in showing how that species differs from it. Fowler follows Signoret in his treatment of the species, and under remarks on *tartarea* describes the genitalia of *obtusa* as like that of our *undata*. He follows Signoret in the synonomy of *undata* and adds *marginata* and its three synonyms; he, however, places *undata* on a very pale form, which he figures, and then describes *alpha* as a possible variety, while in fact it is nearer the typical form, His next species, *rubescens*, and a previous one, *interjecta*, seem also to belong to the *obtusa* group. He suggests *tartarea* and *funebris* as coming in there, but specimens in hand from Mexico which agree with the descriptions of these species are quite distinct. The *funebris* is given as from Calif. by Signoret, but no specimens of it have been seen from there, and it has not been included in the synopsis; possibly Lower Calif., Mexican, is meant.

If, on further examination, the above conclusions prove to be correct, then the full synonmy of *obtusa*, as far as known, will be, in addition to the above, all of which will come under the variety *undata*, as follows:

Cicada obtusa, Fab. Mantissa Ins., p. 269, 1787.
Proconia parallela, Walk. Homop. III, p. 788, 1851.
Tettigonia facialis, Sign Monog. An. Sc. Ent Fr., p. 489, 1854.
Tettigonia herpes, Sign. Monog. An. Sc. Ent. Fr., p. 796, 1855.
Oncometopia obtusa, Fowl. Bio. Homop. II, p. 228, 1899.
? *Oncometopia interjecta*, Fowl. Bio. Homop. II, p. 228, 1899, pl 14, fig. 12.
? *Oncometopia rubescens*, Fowl. Bio. Homop. II, p 233, 1899, pl. 14, fig. 24.

Several more of Fowler's species may fall in this list when the Mexican forms are more thoroughly known. His descriptions are very meagre, and he evidently paid little or no attention to genitalia, so that it is very hard to definitely place any of his species until a specimen comes to hand that has the exact color pattern that he described. as he rarely makes any provision for variation in his descriptions.

For the northern part of its range this species seems to be very constantly of the form figured, but farther south the smaller and darker varieties appear, none having been received, however, from nearer than central Mexico. From the extreme southern part of our range (Florida and Texas), a variety that is somewhat shorter and more robust, proportionally, has been received. These specimens are usually very obscurely marked, and of a uniformly dull brown color, but the head pattern and genitalia are identical with the common form.

The color pattern of the head is quite definite in all of the varieties, except the very darkest, where it is obscured, but even here the "A" of the vertex, and the lines of the front can usually be traced in an oblique light, and form one of the best characters for distinguishing this species. Fowler speaks about the color pattern of the pronotum serving to separate this species. This is one of the most variable things about it, and it is little wonder that with such a character as a guide be added to the confusion, instead of helping to clear up the synonomy.

ONCOMETOPIA LATERALIS FAB.

Cicada lateralis, Fab. Ent. Syst. Sup., p. 524, 1798.
Cicada marginella, Fab. Syst. Rhyng., p. 96, 1803.
Cicada costalis, Fab. Syst. Rhyng. Erata following, p. 314, 1803.
Tettigonia striata. Walk. Homop. III. p. 775, 1851.
Tettigonia lugens, Walk. Homop. III. p. 775, 1851.
Tettigonia pyrrhotelus, Walk. Homop. III; p. 775, 1851.

Much shorter than *undata* but nearly as broad; eyes not as prominent. Black, coarsely irrorate with yellow; Elytra red, veins black. Length, 7-8 mm.; width, 2.75 mm.

Head and pronotum but slightly inclined, eyes moderately prominent, vertex slightly obtusely angled, twice as long on middle as at eye, length equal to half its basal width, four-fifths the pronotal length. Front moderately gibbous, sloping back from the plane

of the vertex, very roundingly angled below. Elytra broad, and short, the costral area wider than adjacent cells, first sector forking before the cross nervure.

Color; vertex and pronotum black, coarsely and irregularly dotted with yellow; on the pronotum the wrinkles are yellow, the pits black. Scutellum black, broken lines on the margins, a median line on the posterior half, and a pair of lines on anterior disc enclosing a number of yellow spots. Elytra red, with the nervures black; sometimes the disc is slaty blue, with light margins to the nervures. Front black, with round white spots. Below black, sometimes marked with yellow. As seen from side, a narrow yellow line extends around the vertex in front on a level with the eye and runs from the lower corner of the eye to the lateral margin of the abdomen and on back to the pygofers.

Genitalia; female segment twice the length of the preceding, truncate, or very slightly emarginate posteriorly, the lateral angles often depressed, leaving a semicircular disc; male plates, triangular, one-fourth longer than their basal width, as long as the pygofers.

Specimens are at hand from Ontario, District of Columbia, Virginia, Florida, Alabama, Tennessee, Mississippi, Manitoba, Minnesota, Iowa, Dakota, Nebraska, Arkansas, Texas, Montana, Wyoming, Colorado, Idaho, Washington, New Mexico, and Nicaraugua, Central America.

VAR LIMBATA. SAY.

Tettigonia limbata, Say. Jour. Acad. Nat. Sc., Phila., IV, p. 340, 1825.
Tettigonia septentrionalis, Walkr Homop. Supp., p. 193, 1858.

Usually somewhat smaller and narrower than the typical form, often with longer elytra, which gives them a somewhat linear appearance.

Color, shining black, vertex and face usually with a few rather large yellow spots; pronotum with two ocellate orange spots well back of the anterior margin and in line with the ocelli; sometimes another pair on the outer angles of the scutellum. Below black, the lateral line extending from the eye back, broad and distinct.

Specimens of this variety are at hand from Colorado, Dakota and Iowa, and it has been reported from Michigan and Canada, and Walker's species was from the Mackenzie river. The white lateral line will at once separate it from the black form of *T. hieroglyphica*, which it somewhat resembles.

The species, as a whole, occurs from the Mackenzie river and Nova Scotia south throughout the whole continent, and to northern South America at least. It is somewhat

local in distribution in some parts. In Colorado it occurs everywhere, but in Iowa it has only been found in a few places along the northern border, and yet it occurs alongside in Missouri and Nebraska. This species is very varible in size and color, the black on vertex and pronotum is fairly constant, while the elytra vary from a bright red to a bright slaty blue and on to shining black, and the irrorations on head and pronotum vary from white to orange, and in some Central American specimens they are rufus. The lateral white stripe, however, remains constant, and will at once distinguish this species.

Fowler, in the Biologia, places this species under *Tettigonia*, along with *punctulata*. This is an error; the resemblance is only superficial. *Lateralis* possesses the angled front, the sulcate anterior tibiæ and the exposed lateral margin to the abdomen, which make it a good *Oncometopia*, and widely separates it from *punctulata*.

GENUS HOMALODISCA, STAL.

Head, large; eyes, prominent, wider than pronotum; vertex and pronotum, inclined; vertex, triangular, the apex obtuse longer than pronotum, the disc with a distinct median furrow. Front and vertex forming an acute angle, the apex bluntly rounded. Front, flat in same plane as clypeus, the disc flat or concave. Pronotum, short, quadrangular, narrowing posteriorly. Elytra, hyaline or sub-hyaline, rarely coriaceous, the claval nervures often united for a considerable distance in the middle. Anterior tibiæ, sulcate above, often broadened apically.

This genus is closely related to *Phera*, of Stal, but may be known by the broader apex of the vertex and the flat or depressed front.

KEY TO THE SPECIES.

A. Elytra, hyaline, at least on basal half, the nervures distinct, apparently raised.
- B. Vertex, but slightly longer than pronotum, evenly irrorate, with fuscous; usually several irregular, reticulate veins between the first cross nervure and the fork of the first sector.......................*triquetra*, Fab.
- BB. Vertex, one-half longer than pronotum, irregularly lined with fuscous, no extra cross-nervures between the sectors of elytra....................*liturata* n. sp.

AA. Elytra, opaque, the nervures concolorous, the first sectors forked half way between the first cross-nervure and the second ....*insolita* Walk.

HOMALODISCA TRIQUETRA FAB., Plate II, Fig. 1.

Cicada triquetra Fab. Syst. Rhyngt.. p. 63. 1803.
Tettigonia vitripennis Germ. Mag. Ent. IV, p. 61, 1821.
Tettigonia coagulata Say. Insects, La.. p. 13, 1832.
Tettigonia ichthyocephala Sign An. Soc. Ent. Fr., p. 494, 1854. (vide Fowl).
Proconia admittens Walk. Homop. Supp., p. 227 1858.
Proconia aurigera Walk. Homop. Supp., p. 228, 1858.
Phera vitirpennis Fowl. Bio. Homop. II, p 221, Plate XIV. Figure 1, 1899.

Longer and narrower than in the former genera, with a broad, triangular head, which is rounded at the apex. Elytra, hyaline. Length, 13 mm.; width, nearly 3 mm.

Vertex, as long as its basal width, one-fifth longer than pronotum; disc, flat, sloping, with a median furrow and a depression before each ocellus, apex very bluntly rounding, the lateral margins sharp. Front, sloping, disc concave, rounding up to meet the vertex in a right angle. Pronotum, very coarsely pitted, anterior and posterior margins nearly parallel. Elytra, with the venation strong, usually two or three irregular cross-nervures between the sectors at or before the first fork, the claval veins coalescing for a short distance, then widely separated. Anterior tibiæ, sulcate above and somewhat widened apically.

Color; vertex and pronotum deep testaceous brown, finely and regularly irrorate with yellow sometimes obscuring the brown. Elytra smoky subhyaline usually a broad, somewhat milky band, before the middle and an opaque red spot before the apical cells which sometimes extends forward along the costa. Fresh specimens often have a pruinose spot just before the red one. Face and thorax below orange yellow, a spot on clypeus, sometimes a pair on face, the upper side of anterior tibiæ, mottled on all the femora, and spots from which the spines on hind tibiæ arise, black. Abdomen blue-black above, the lateral margins, broadly on the two basal segments, narrowly beyond, ivory white, the spiracles and a few spots along margin brown. The pygofers orange, abdomen below whitish, the disc of each segment black.

Genitalia; female segment about twice the length of the preceding, slightly narrowing to the lateral angles which are acute, between these the posterior margin is triangularly incised one-third its depth, the apex of the incision is blunt and the margins sinuate. Male plates long, triangular, slightly, concavely narrowing to an acute apex.

Specimens are at hand from Georgia, Florida, Alabama, Louisiana, Mississippi, Texas, and Mexico, and it has been reported from South Carolina. It seems probable that the references of this species to California belong to the following species.

The above synonomy is given with some hesitation. Fowler figures it under the name of *vitripennis* and does not include *triquetra* at all. He evidently had our species

in hand, but his references of *ichthyocephala* Sign. to this form seems doubtful.

HOMALODISCA LITURATA N. SP. Plate II, Fig. 2.

Smaller, narrower than *triquetra* with a longer head. Straw yellow, five irregular brown lines on the head. Length, 11mm; width, 2.25mm.

Vertex one-fifth longer than its basal width, half longer than the pronotum, disc flat, very deeply grooved in the middle. Front very long and narrow, disc flat and in same plane as the clypeus. Pronotum short, disc flat, posterior margin more strongly curved than the anterior one. Elytra very narrow, nervures distinct, a single cross nervure between the sectors situated at over one-third the distance from the fork of the first sector to the base.

Color; vertex pale yellow with five brown lines as follows: a narrow median one expanded on the apex, an interrupted line on either side the middle, arising considerably back of the apex and usually somewhat reticulate anteriorly, a pair of heavier stripes arising either side the apex and running back to the ocelli, their basal portions forming part of the loop that runs from the ocelli around to the eye, the striations of the reflexed part of the front brown. Pronotum yellow, irregularly punctured with brown; usually four distinct dark spots on the anterior submargin. Scutellum yellow with large brown spots sometimes arranged in the form of an H. Elytra hyaline, the nervures red, an irregular opaque red patch on the costal half back of the middle, terminating just before the apical cells and omitting an oval hyalin spot in the anterior end of the anteapical cells. Face and legs yellow, a spot on apex of front and anterior tibiæ, fuscous. Abdomen black above, the terminal segment yellow, the lateral margins broadly white, at the base, narrowing apically, the spiracles dark. Below pale, sometimes a median line and the margins of the female segment black.

Genitalia; female segment half longer than the penultimate, the lateral margins parallel, the posterior margin in two slightly rounding divergent lobes, the notch between them narrow and less than half the depth of that in *triquetra*.

Specimens are at hand from Phoenix, Ariz; Yuma, California, and Comondu Lower, Calif, Mexico. The larger head and much narrower form together with the lineate arrangement of the markings will readily separate this form from *triquetra*.

HOMALODISCA INSOLITA WALK. Plate II, Fig. 3.

Preconia insolita. Walk. Homop. Supp., p. 227, 1858.
Phera insolita, Fowl. Bio. Homop. II., p. 222, pl. xiv, fig. 2, 1899.

Resembling *triquetra*, but smaller and with a smaller head. Dark testaceous, with the anterior half of pronotum and vertex irrorate with yellow. Male sometimes almost black. Length, 10.5 mm.; width, 2.25 mm.

Vertex, no longer than the pronotum, very flat, but little inclined, margins acute, nearly right angled before. Front, convex, disc flat above. Face, as seen from side, much deeper than in *triquetra*, the outline sinuate. Elytra, rather broad, coriaceous; venation, regular, not prominent, the claval veins united for a short distance, the cross-nervure at about the middle of the first sector.

Color: dark reddish brown; a slightly olive tinge in the female. Vertex and anterior half of pronotum irrorate with pale yellow, sometimes a light median line in the furrow. Male very much darker, almost piceus on pronotum and elytra. Front and below, orange yellow; an ivory band arises on either side the apex of the vertex, below which it is indistinct, running back below the eyes, widening on the thorax and narrowing again on the margin of the abdomen. This stripe is narrowly margined with black, above and below, on the thorax. Fore tibiæ, dark fuscous.

Genitalia: Female segment twice longer than penultimate, the posterior margin triangularly emarginate. The emargination rounds off into a narrow median slit, which extends two-thirds of the distance to the base. Male plates about as long as the ultimate segments, equilaterally triangular, rather stout.

Specimens are at hand from Texas and Arizona, and it is reported from several points in Mexico in the Biologia. The evenly coriaceous elytra readily separates this from either of the other species. Neither Walker nor Fowler describe the genitalia, which is quite distinct, but there seems little doubt but that this is the form Walker described.

GENUS TETTIGONIA GEOFF.

Head, bluntly conical, but slightly sloping, eyes rarely prominent; ledges over antennal sockets, as seen from above, fused with the vertex margin at apex, not prominent. Front, convex, but not gibbous; vertex convex, confused with the rounding front. Pronotum, rather long, broadest at the lateral angles, the lateral and humeral margins nearly equal in length; posterior margin straight or roundingly emarginate. Elytra, covering the abdominal tergum; venation, simple non-reticulate, often obscured by the color markings. Anterior tibiæ simple.

This genus is world-wide in distribution, and contains a very large number of species of many different forms. Our

species very readily fall into two groups, the first of which under "A" is the more typical and would include most of the tropical species. The second group, "AA," has a reduction in the number of cross-nervures, narrower heads, and the face pushed downwards and forwards, instead of rounding back at the apex, giving the head a much greater depth. This is extremely emphasized in *tripunctata*, and if it occurred here alone there might be reason for generic separation, but a most complete gradation in this character is found running back from this species through *bifida*, *hartii*, *occatoria* and *gothica* to the other extreme in *hieroglyphica*.

KEY TO THE SPECIES.*

A. Elytra with three anteapical cells; head as wide as the pronotum, not as deep as the length of vertex and pronotum together. Face, in profile, strongly curved backwards, usually with the clypeus somewhat angled.
- B. Head with a pattern sometimes obscure, but not in the form of definite spots.
  - C. Head pattern very complex, no parallel lateral bars. Length, over 6 mm...... *hieroglyphica* Say.
  - CC. Head pattern simple, the lateral bars running back parallel with the median pair. Length, 6 mm. or less .... *gothica* Sign.
- BB. Head with definite spots, not coalescing into a pattern.
  - C. Greenish blue, face with two stripes, posterior half of pronotum with black spots .... *atropunctata* Sign.
  - CC. Reddish, face with three stripes, posterior half of pronotum with four longitudinal stripes........ .... *dohrni* Sign.

AA. Elytra with no cross-nervures between the branches of the first sector before the apical cell (occasional in *occatoria*). Head narrower than pronotum, deeper than the length of vertex and pronotum. Face, in profile, straight or in a single curve, rather long.

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*NOTE:—*Tettigonia lineata* Sign. (= *coeruleovittata* Sign.) although credited to the "United States" in the original description, has not been included in this synopsis as no specimens have been seen from points nearer than central Mexico, and it seems probable that the original reference was an error.

Tettigonia aestuans Walk. is credited to California by Van Duzee, in his catalog, on what authority I do not know. Walker gave "West Coast of America" and Signoret "Para" as habitat for this species. It belongs to a group of distinctly tropical forms, and is doubtless South American in distribution.

B. Head and pronotum with definite longitudinal stripes. ....*occatoria* Say.

BB. Head and pronotum with transverse bands parallel with margin, or none.

C. The outer branch of the first sector forking to form an anteapical cell. Pronotum with transverse bands parallel to the margins.

D. Green, vertex blunt, alternate transverse bands of light and dark on pronotum and vertex.

E. Elytra green, the nervures black. Length, 5.5—6 mm........*bifida* Say.

EE. Elytra green, the nervures pale or obscure, three white spots before the the apex. Length, 4.5—5 mm., much narrower than above.*geometrica* Sign.

DD. White, vertex longer, with three black spots. Elytra white, the nervures brown. ....*tripunctata* Fitch.

CC. The outer branch of the first sector, with its outer fork running to the margin. Pronotum, without marginal bands. Form, short and stout. .... *hartii*

TETTIGONIA HIEROGLYPHICA SAY. Plate III.

Tettigonia hieroglyphica Say. Jour. Acad. Nat. Sc. Phil. VI, p. 313, 1831.

Rather stout; vertex bluntly conical. General color, reddish or greenish on pronotum and elytra usually mottled, costa and claval suture often broadly light, the markings on vertex in a complex pattern. The broad median band of scutellum light. A black spot on apex of vertex. Face, mottled; sometimes the whole insect is black. Length, 6—7 mm.; width, 1.5 mm.

Vertex, slightly conical, bluntly right-angled, the lateral margin in advance of the margin of the eye; over three-fourths the length of the pronotum not quite three-fourths its basal width. Face, as seen from side, rounding back. Elytra, rather broad and compact; five apical and three anteapical cells.

Genitalia; female segment two and one-half times as long as the penultimate, slightly narrowing posteriorly; posterior margin triangularly produced, the apex produced and rounding, who e segment thin and membranous, strongly curved around the pygofers. Male plates two and one-half times as long as the ultimate segment, long-triangular, their apices acute, margins fringed with soft hairs.

The following varieties intergrade, but most of the specimens will readily fall into one of the following forms:

VAR. HIEROGLYPHICA, SAY. Plate III, Fig. 1.

Red form—Structure as above. Color, a round black spot on the apex of vertex and face surrounded by a broad circular

band of white; from this on either side there is a band around the margin of the vertex to the eye, and usually a band runs down the middle of the front. Front irregularly mottled with black and white. Lorae and genae pale, clypeus white, with a median black band. Vertex with a median light line arising from a transverse spot at base, forking just before the middle the two forks angularly divergent, and again angularly recurved, forming a T, with the top piece broken upward to form nearly a right angle above; a band against either eye, from the anterior end of which a crescent extends in, nearly to the top of the T, an oblique line running in from behind either eye, sometimes interrupted to form a spot just inside either ocellus, white. Pronotum, reddish, with irregular creamy markings, usually the anterior margin is lighter, with definite markings, often a creamy band extends back from either eye and joins a band around the posterior margin. Scutellum, with the median half white, interrupted in the middle, a pair of round black dots in the anterior quadrangular part, a pair of white dashes along the middle of the lateral margins. Elytra, reddish, the costal and sutural margins, a line on either side the claval suture and a line between the claval nervures pale creamy, sometimes some irregular mottlings on the disc of the corium.

Slaty form—Size and structure of the preceding form. Color slaty green, varying to fuscous, markings as in the preceding species, except that the light markings of the vertex are usually reduced in size. Face in the female often nearly all light, except for the black spots on the clypeus and apex of head; in the male, often black, with small light spots. Pronotum with a pale area behind each eye, in the middle of which there is a black spot, the dark marking along the anterior margin sometimes forming definite spots. Light stripes on elytra, often broad, especially the pair next the claval suture. Light markings, often with a tinge of blue.

VAR. DOLOBRATA NOV. VAR., Plate III, Fig. 2.

Somewhat smaller than the preceding. Shining black, a few of the white markings of the typical form persisting, as follows: the margins of the clypeus, the genae, a line below the margin of the pronotum, the circle around the apex of head, a line against the eye, and the marking of the scutellum. Often there is part of a median line on vertex and a pair of slender lines running from the inner corner of the eye back across the pronotum to the light margined claval suture.

VAR. UHLERI NOV. VAR., Plate III, Fig. 3.

Slightly stouter than typical *hieroglyphica*, elytra often considerably longer; grayish green, with light blue-green mottlings; black markings on vertex and scutellum much reduced in size and intensity, remaining only as narrow lines margining the original white pattern, giving quite a strikingly different appearance to the vertex. The whole central area is now light from the apical circle back, a pair of approximate lines on the basal half and a heavier pair between them and the ocelli converging before the middle. The

areas between the ocelli and the eyes are light, often partly enclosed by a black circular line and with a heavy black spot in the middle. The reflexed portions of the front striated with dark. Pronotum, as in other forms, the markings smaller and more numerous. Elytra mottled with blue-green, the nervures somewhat fuscous, claval sutures often broadly light.

Reddish form—Reddish, pronotum and elytra mottled with creamy, anterior margin of pronotum and scutellum distinctly reddish, dark markings often obscure or wanting, the outer pair of lines on vertex often enlarged, somewhat lobed.

VAR. CONFLUENS UHL., Plate III, Fig. 4.

Proconia confluens, Uhler. Proc. Acad. Nat. Sc., Phila., p. 285, 1861.

Stouter than even the preceding varieties, elytra usually long nearly parallel margined. Dark testaceous, shading to fuscous, elytra slightly and obscurely mottled. Vertex and scutellum fuscous, a few of the light markings of *uhleri* persisting, as follows: a dash back of the apex of vertex, three lines on the disc, a transverse spot at base and a margin next the eyes. Often light markings on pronotum, the lateral ones arranged in rows, apex of scutellum light. The face is usually light, with dark mottlings. Elytra often with the mottlings arranged in light stripes, especially along costa and claval suture.

This species, as a whole, is very variable in size and color, and recalls *O. undata* and *lateralis* in their red, green and black forms. The varieties readily fall into two series on structural characters. The first has *hieroglyphica*, and *dolobrata* as the extreme in darkening up. These forms are the only ones found in the Mississippi valley and as far west as central Kansas; they occur also in Texas, Arizona and Mexico. The second series has *uhleri* as the common form, and *confluens* as the dark extreme. The *uhleri* is the common form in Wyoming, Colorado, Arizona and New Mexico, and extends westward to the coast. The specimens from the western coast, including Idaho, are much larger, and have longer elytra, and are mostly *confluens*.

Specimens of this species are at hand from Illinois, Iowa, Missouri, Nebraska, Kansas, Arkansas, Texas, Wyoming, Colorado, Utah, New Mexico, Arizona, Idaho, Washington, Vancouvers Island, Oregon, California and Mexico. All specimens received as *hieroglyphica* from points east of Illinois belonged to the following species:

TETTIGONIA GOTHICA SIGN., Plate IV, Fig. 1.

Tettigonia gothica Sign. An. Soc. Ent. Fr., p. 345, 1854.

Tettigonia similis Woodw. Bull. Ill. St. Lab. III., p. 25, 1887.
Tettigonia hieroglyphica, in ref. from Eastern States (nec Say).

Smaller than *hieroglyphica*, which it much resembles, pale reddish or grayish green, with several nearly parallel lines on the disc of the vertex and a point at apex black. Length, 5.5—6 mm.; width, 1.25 mm.

Vertex slightly narrower and more pointed than in *hieroglyphica*, three-eighths wider than its middle length, over two-thirds the length of the pronotum, the margins rounded, apex slightly conical, the lateral margin rounding directly to and confluent with the margin of the eye. Front and clypeus as seen from side are evenly rounding, the rostrum reaching back to the scutellum. Elytra with the nervures somewhat more pronounced than in *hieroglyphica*, venation similar.

Color; head pale reddish or greenish yellow, apex with a black point surrounded by a light circle. Front all light or with a light median stripe and numerous short fuscous arcs. Clypeus unmarked or with but a minute black point. Vertex with the margins of the reflexed portions slightly angularly lined, a line from the angle following the suture to the ocelli, inside of these on the disc there is a pair of loops, their outer limbs often curving around to the ocelli and sending a branch back to the posterior margin. These loops often reduced in size to feeble lines, and their inner limbs sometimes broken or wanting. Pronotum with the anterior third light yellow, disc olive or brownish, sometimes with a distinct pattern, often without definite marking. Scutellum with the median half of posterior disc light, margins and anterior disc often clouded with fuscous. Elytra grayish green or reddish unicolorous with the nervures light, or mottled with creamy yellow, the nervures slightly darkened.

Genitalia; female segment nearly three times the length of the penultimate, the posterior margin triangularly produced, whole segment transversely convex. Male plates long, triangular, two and one-half times as long as the penultimate segment, nearly half longer than their combined basal width, their margins fringed with hair.

Specimens have been examined from Maine, New Hampshire, Vermont, District of Columbia, New York, Ohio, Illinois, Kentucky, Alabama, Iowa, Nebraska, Kansas, Colorado, Arizona and southern California; and besides these, it has been reported from New Jersey (*similis*), and Ottawa, Can. and Massachusetts (as *hieroglyphica*). This species has been very generally confused with *hieroglyphica* and reported under that name. All specimens determined as that species that have been received and examined from points east of Illinois have proved to

belong to this one, and it seems quite certain that all records for *hieroglyphica* from farther east than that, should be referred to this species. Typical examples of *similis* determined by Woodworth have been examined.

TETTIGONIA ATROPUNCTATA SIGN., Plate IV, Fig. 2.

Tettigonia atropunctata Sign. An. Soc. Ent. Fr., p. 354, 1854.
Tettigonia cir illata (Uhler MS.). Baker (descrip.) Psyche VIII, p. 285, 1898.
Tettigonia atropunctata Fowl. Bio. Homop. II, p. 256, Pl. 17, Fig. 27, 1900.

General form of *hieroglyphica* somewhat narrower, vertex and pronotum each with about five black spots. Posterior half of pronotum and elytra blue. Length, 6—7 mm.; width, 1.25 mm.

Vertex bluntly rounded, slightly narrowed at the eyes, two-thirds the length of the pronotum. Face, as seen from side, similar to *gothica*, clypeus slightly prominent, elytral venation similar to that of *gothica*.

Color; head pale yellow, sometimes washed with pale blue, a black spot at the apex, surrounded by a pale circle. Front with a stripe either side of the middle, the lateral margin and the clypeal suture black, the two stripes are often effaced in the middle, leaving only a dash at the ends, clypeus with a black dash, vertex with a spot on the middle, a dash against each ocellus on the outside, and a crescent on either side anteriorly along the line of the frontal suture. Pronotum with the anterior half pale, broadest behind the eyes, a black spot behind the outer corner of either eye, a pair just inside the eyes on the sub-margin, and three dots between these latter. Posterior half bright blue, with a large transverse spot behind the middle on either side, and a small dot or longitudinal spot between them. Elytra bright blue, the nervures narrowly black. Legs, orange.

Genitalia; female segment three times the length of the preceding, the median line elevated into a strong keel, posterior margin strongly angled, the apex formed by the convex keel. Male plates long, slender, style-like, about three times the length of the ultimate segment, the margins with fine hairs.

Numerous specimens are at hand from Arizona and California. It is reported as being one of the most abundant and injurious Jassids in southern California.

Signoret described this species from Brazil, and Fowler has it (figured) from Mexico. Neither author's figures are very good for the insect as it occurs in our territory, but Signoret's description, which is very full and complete, and includes face markings and genitalia, both very striking and distinctive, leaves no doubt as to this being the species

described. Specimens labeled *circillata*, in Baker's handwriting, are in the National Museum collection.

TETTIGONIA DOHRNII SIGN. Plate IV, Fig. 3.

Tettigonia dohrnii Sign. An. Soc. Ent. Fr., p. 792. Pl. 24, Fig. 13, 1855.
Tettigonia aurora (Uhler MS.) Baker (description) Psyche VI, p. 286, 1898.
Tettigonia dohrnii Fowl. Bio. Homop. II, p. 268, 1900.
Tettigonia delicata Fowl. Bio. Homop. II, p. 269, Pl. 18, Fig. 5, 1900.

Resembling *atropunctata* in structure, rather longer and narrower. Head and anterior part of pronotum pale, with transverse rows of spots, rest of pronotum and elytra pale reddish, with darker stripes. Length, 7 mm.; width, 1.25 mm.

Vertex, bluntly rounding, three-fourths the length of the pronotum, narrower than in the preceding species, the disc very flat, slightly transversely depressed. Eyes, small, hardly as wide as the pronotum at the lateral angles; pronotum, rather long, narrowing anteriorly. Elytra, long and narrow; venation of the *hieroglyphica* pattern, the anteapical cells longer and narrower; outline of face as in that species.

Color; vertex, pale creamy; a spot at the apex, which is one of five equidistant ones on the anterior margin, and behind these a pair of oblique dashes with their inner ends enlarged and obliquely truncate; black. Posterior sub-margin with four quadrate reddish spots, the inner pair elongate. Front, pale; three longitudinal lines, the median line not reaching the apical dot, either side of which there is a black dash below, a pair of spots below the antennal pits, another pair below these, and a third pair on the geræ. Clypeus, with a black dash above. Pronotum, with the anterior part light, broadening out behind the eyes, the sub-margin with six quadrangular reddish fuscous spots in a row; posterior disc tinged with reddish, with four longitudinal testaceous lines, the outer pair short and divergent; scutellum, yellow, with the transverse suture, and three dots at base, reddish fuscous; sometimes the basal dots are extended into longitudinal lines. Elytra, broadly pale along the nervures, the central portion of the cells darker. Legs, yellow.

Genitalia; female segment over twice the length of the penultimate; posterior margin, broadly roundingly produced; disc, convex. Male plates, one-third longer than the ultimate segment; rather broad at base, rapidly narrowing to the long acute points, which are much exceeded by the pygofers.

Specimens are at hand from Arizona and Mexico. The Arizona specimens are from the Van Duzee collection, and bear the label, "Ariz. C. U., Lot 34," and under this, "Cornell U., Lot 45, Sub. 410." They were sent to Prof. Van Duzee as *T. aurora* Uhler, and are doubtless from the

same lot as the two specimens Baker described. The Mexican specimens are paler and answer the Signoret description, except that there are four longitudinal stripes on the pronotum. One of the Arizona specimens has the median pair coalesced, which would give the three stripes of his description and figure.

TETTIGONIA OCCATORIA SAY. Plate IV, Fig. 4.

Tettigonia occatoria Say. Jour. Acad. Nat. Sc. Phila. VI, p. 311, 1831.
Tettigonia compta Fowl. Bio. Homop. II, p. 271, Pl. 18, Fig. 11, 1900.
Tettigonia occatoria Fowl. Bio. Homop. II, p. 279, Pl. 18, Fig. 29, 1900.

Smaller than *dohrnii*, which it resembles in form; longer and narrower than *gothica*. Pale, with four divergent stripes on head and five parallel ones on pronotum; dark brown. Elytra, with a transverse white band before the apex. Length, 6 mm.; width, 1 mm.

Vertex, nearly flat, rather long, angled with a blunt point, the length and breadth at base equal; almost as long at pronotum. Pronotum, broader than the eyes. Elytra, long and narrow; venation, obscure; two apical cells, sometimes three. Outline of face, as seen from side, almost straight, resembling *bifida*.

Color; vertex, yellow, a black spot on the apex just below the margin; a stripe arising just outside and behind the apex on either side running back between the ocellus and the eye; a median dash some distance from apex, which abruptly terminates in a pair of stripes, which run back parallel with the first pair, but inside the ocelli. Pronotum, with five stripes, the median one arising on the base of the vertex and continuing to the apex of scutellum; another pair of stripes arising beneath the eyes and running back below the margin of the pronotum onto the elytra, where, together with the two pairs from the head, they break up into six stripes on each side, of which the outer pair furnishes three on the corium and the other two pairs the three on the clavus. These stripes are of a velvety brown, the outer pair darker anteriorly. The space between these stripes, the margins of the elytra, except the apical, some shade of yellow. Just before the apex of the elytra is a crescent-shaped, transverse band, which may be yellow or hyaline. Face and below, pale yellow; a few short fuscous arcs on the side of the front. Legs, pale.

Genitalia; female segment scarcely twice the length of the preceding; posterior margin obtusely rounding or almost truncate. Male ultimate segment very short; plates rather broad-triangular, their apices slightly produced; much exceeded by the pygofers.

Specimens are at hand from Florida, Mississippi and Texas, where it is apparently common. It is also a common Mexican insect. Specimens are at hand from many localities, but the two commoner forms are somewhat

different in color and both strikingly different from the form from the United States. One of these forms has the stripes black, the disc of the pronotum and elytra blue-green, with very faint stripes; often a bright blue band inside the claval suture. The other variety has the stripes very broad and definite, of a blue-black; the spaces between the stripes yellow on vertex, becoming greenish on the pronotum and bright green on the elytra. Throughout this variation the structure and pattern remains the same, except that the transverse light band at the apex of the elytra is often much broader or doubled by a narrow, black line. Fowler figured this latter variety as *occatoria*, and described our common form as *compta*. His two following species, *tunicata* and *sororia*, probably also belong here.

TETTIGONIA BIFIDA SAY. Plate V., Fig. 1.

Tettigonia bifida Say. Jour. Acad. Nat. Sc., Phil. IV, p. 313, 1831.
Tettigonia tenella Walk. Homop. III, p. 770, 1851.
Tettigonia fasciata Walk. Homop. III, p. 780 1851.
Tettigonia bifida O. & B. Ia. Acad. Sc. IV, p. 175, 1897.

Head short and blunt. Color green, alternate circular bands of light and black on head and pronotum, nervures broadly black. Length, 5.5—6 mm.; width, 1.2 mm.

Vertex short, conical, half the length of the pronotum, nearly twice wider than long, eyes small, narrower than pronotum at the lateral angles. Elytra broad, venation simple, no cross nervures between the sectors before apical cells, outer fork of first sector again forking near its middle. Face, as seen from side, very gently curved.

Color; vertex black, the concave posterior margin with a light band which extends behind the eyes, another light band parallel with this across the disc, just in front of the ocelli, a spot on either side of the apex, sometimes connected with the anterior band by divergent lines. Ledge above antennæ black, margined with light. Face pitchy, outer margin of genæ and the suture between front and genæ narrowly light, sides of front against antennæ rufous. Pronotum with a broad black band on the anterior margin, broadest in the middle, bordered behind by a narrow light band, the humeral and posterior margins with a narrow band of ivory white, in front of which there is a broader band of black, sometimes this band margined in front by another pale one, the disc green. Scutellum yellow, with the transverse impression black. Elytra green, the nervures black, except for the apical cells, which are entirely smoky. Legs, yellow.

Genitalia; female segment about half longer than the preceding one, the posterior margin with the median half slightly roundingly produced, whole segment very convex. Male plates scarcely as long as the ultimate segment, equilaterally triangular, their apices slightly divergently produced. Plates less than half the length of the pygofers.

Specimens are at hand from New Hampshire, Vermont, New York, District of Columbia, Ohio, Iowa, Kansas, Florida, Tennessee, Alabama, Mississippi, Mexico and the West Indies. It occurs all over the eastern half of the United States from Canada to Florida, west to Iowa and Mississippi, and on into eastern Kansas and Nebraska; but a careful search in the west ends of these states and in Colorado has failed to find it.

TETTIGONIA GEOMETRICA SIGN. Plate V, Fig. 2.

Tettigouia geometrica Sign. An Soc. Ent. Fr., p. 12, Pl. 1, Fig. 12, 1854.
Tettiyonia geometrica Bak. Psyche VIII, p. 285, 1898.

Resembling *bifida* in form and color, but smaller and lacking the black lines on the elytra. Length, 4.5--5 mm.; width, scarcely 1 mm.

Vertex slightly shorter than in *bifida*, elytra narrower, venation similar, the fork of the outer branch of the first sector occurring well behind the middle instead of at or before it, as in *bifida*, and its branches somewhat more divergent.

Color; vertex black, with the two light crescentiform bands as in *bifida*, the anterior one narrower and almost broken on the frontal sutures; the two spots at the apex larger, approximate. Face black, the antennæ and the margins of the ledge above light. Pronotum and scutellum as in *bifida*. Elytra bright green, the apical cells smoky, margined in front by three pale spots, the outer one the largest; the costal margin and usually the outer branch of the first sector light yellow. Some Florida males are much darkened up, but the light spots on the wings remain or become enlarged.

Genitalia; as in *bifida*, but so much smaller that they are made out with difficulty.

Specimens are at hand from the District of Columbia, Ohio, Kentucky, Florida, Arkansas and Mexico. Besides these, it has been reported from Illinois, Alabama and Louisiana. The Ohio River seems to be nearly its northern limit, as it has only been taken in southern Ohio and Illinois, and careful collecting in Iowa has not revealed it. It doubtless occurs throughout all the Southern States from

Maryland and Illinois south to Florida and Texas, and on through Mexico to South America.

Readily separated from *bifida* by the much smaller size and the green elytra with the three white spots before the smoky apex. Some Florida males are almost black, and might be confused with *hartii* males, if they were not so much more slender than that species.

TETTIGONIA TRIPUNCTATA FITCH. Plate V, Fig. 3.

Tettigonia tripunctata Fitch. Homop. N. Y. St. Cab., p. 55, 1851.
Not *Tettigonia tripunctata* Sign. Monog. No. 175; Fowler Bio., p. 253.

Resembling *bifida* in form and structure, smaller, and with a longer head. White, with the nervures and three spots on vertex, black. Length, 5 mm.

Vertex long, conically pointed, almost as long as the pronotum. Pronotum as wide as the eyes at the lateral angles, narrowed in front. Elytra inclined to be flaring, venation simple, no cross nervures between the sectors, the second fork of the first sector occurring beyond the middle of the outer branch, the two veins often scarcely separated. Face, as seen from side, gently curved, very deep.

Color; white, vertex with a spot on the apex, and circles around the ocelli black, a few brown arcs on the reflexed portion of front and often a brown point on the middle of the disc. Front with very short brown arcs, the ends of which are enlarged and form four longitudinal lines, the two on either side uniting just before the clypeus and extending below the middle of that piece where they unite. Pronotum with the margins very narrowly lined with brown, two transverse bands on the disc, one parallel with each margin, equidistant on the median line, the posterior one abbreviated. Scutellum with an abbreviated median brown line. Elytra with the margins, nervures and claval suture narrowly lined with brown, paler at the apex. Legs and below pale.

Genitalia; female segment nearly twice the length of the preceding, slightly rounding or truncate posteriorly. Male plates broad at base, obtusely triangular, their apices produced into attenuate points; the whole scarcely as long as the large ultimate segment.

Specimens are at hand from Maryland, District of Columbia, New Hampshire, New York, Ohio and Mexico, and it has been reported from Canada, Illinois, Mississippi and Missouri.

The Mexican specimens have the vertex much broader and blunter, as in the Mexican form of *bifida*, and the spot on the center of the disc is distinct and black. Fowler in

the Biologia follows Signoret in his use of *tripunctata*, but as suggested by Van Duzee, Ent. News V, p. 155, this is evidently a mistake and refers to a distinct species which should be called *nigrifasciata* Walk., and which should not only include *pallida* and *albida* but also *uniguttata* and *candida* of Walker. The markings on the head and pronotum are quite different and the genitalia as described by Signoret could not apply to the true *tripunctata*. As described and figured by Signoret *nigrifasciata* should be close to *venusta* Stal., which belongs to the *gothica* group with the retracted face.

TETTIGONIA HARTII, Plate V, Fig. 4.

Tettigonia hartii Wood. MSS.

Form and structure of *tripunctata*, but shorter and much stouter built, especially the head. Female slaty gray, median line of front and nervures lighter. Male much smaller, shining black. Length, ♀ 4.5—15 mm.; ♂ 3.75—4 mm; width, ♀ 1.25 mm.; ♂ scarcely one mm.

Vertex obtusely rounding, conical, two-thirds the length of the pronotum, twice wider than long, the ocelli placed near the anterior margin and on the inner margins of depressed areas. Pronotum broad, flat. Elytra broad, venation similar to *bifida*, a cross nervure forming the inner anteapical cell, the second fork of the outer sector rarely closed behind to form the outer anteapical cell, usually curving away to the costa. Outline of face as seen from side, rounding, face very deep.

Color; female; vertex pale yellowish or brownish, the ocelli and a pair of spots within and behind them, on the posterior margin black. Ocelli often with light circles; in front of the ocelli the vertex is abruptly darker, except for the light spot on apex. Front piceus or brown, a definite median white stripe which enlarges above to form a spot on apex of vertex and often extends onto the dark clypeus below, about twelve pairs of pale arcs on either side. Loræ and genæ pale. Pronotum slaty or brownish, the anterior margin pale, broadening out behind the eyes where it enclosed a black spot; sometimes a pair of spots on the anterior sub-margin behind the basal pair on the vertex. Scutellum pale, a triangular spot within either basal angle. Elytra slaty gray, the nervures pale yellow, claval margins often lined with light blue. Male; shining black, often with circles around the ocelli and the apex of scutellum pale, the spot on apex of vertex white, the median line on front black, the rest of front tinged with rufous, margin of genae pale.

Genitalia; female segment about half longer than the preceding one, posterior margin truncate, slightly incised either side the middle

forming a very slight median tooth; male plates very short, bluntly triangular, not as long as the ultimate segment, less than half the length of the pygofers.

Specimens are at hand from southern Ohio, a pair each from southern Illinois, Florida and Mississippi, and several females from Texas, New Mexico and Cuba. The specimens from New Mexico and Cuba have the elytra very dark, with the light nervures in sharp contrast.

Genus Helochara, Fitch.

Similar to *Tettigonia* in form, head wider than thorax, much broader than long, slightly conical, slightly obtusely angled, reflexed portions of front elevated, prominent. Face well rounded back, profile convex. Pronotum very long, sexangular, resembling *Aulacizes*, lateral margins short, humeral margins very long, the humeral angles rounding to the short medially emarginate posterior margin. Scutellum very small, covered almost to the transverse suture by the pronotum. Elytra coriaceous, veins distinct, raised; venation simple, regular; three anteapical cells and five apical ones. Male antennae with the apical third developed into a flat plate.

Helochara communis Fitch. Plate VI, Fig. 1.

Helochara communis Fitch. Homop. N. Y. State Cab., p. 56, 1851.
Tettigonia herbida Walk. Homop. III, p. 769, 1851. (Not Sign. Monograph No. 167, nor Uhler Hemip. Homop. St. Vinc., p. 77 (=*similis* Walk.))

Small, robust, deep green, superficially resembling *reticulata* or the male of *mollipes* var., *minor*. Length, ♀ 6—7 mm.; ♂ 4—5.5 mm.; width, 1.25 mm.

Vertex a trifle less than two-thirds the length of the pronotum roundly, obtusely angled, the margin blunt, reflexed portion of front prominent, striated. Front sloping well backwards, outline convex or slightly angled above the middle, again on clypeus. Pronotum very long, deeply angled behind. Scutellum very small, less than half the length of the pronotum. Elytra coriaceous except at apex, venation regular, the anteapical cells almost parallel margined. Whole dorsal surface microscopically pustulate.

Color deep green, often fading to pale yellowish olive, except for stripes along the claval suture. The eyes ocelli frontal suture and about four concentric lines on the reflexed portions of front dark. Face and below, pale olive, with about nine dark arcs on front in the female, front usually black in the male.

Genitalia; female segment but little longer than the penultimate, broad and flat, the posterior margin slightly produced in the middle. Male valve broad and short, plates finger-like, triangular, very slightly longer than the ultimate segment.

Specimens are at hand from Ontario, Vermont, New York, District of Columbia, Virginia, Ohio, Tennessee,

Iowa, Colorado, Vancouvers Island, British Columbia and Mexico, and it has been reported from Nova Scotia and Hudson Bay, by Walker. It appears to range the continent from Hudson Bay and British Columbia on the north to at least southern Mexico on the south.

Genus Diedrocephala Spin.

Head narrower than pronotum, eyes small, vertex flat or concave except on posterior margin, roundingly angulate, the apex obtusely rounding, the margins sharp, acute, or very slightly rounded and usually dark lined. Front broad, almost flat above, as seen from side evenly rounding, in the same curve with clypeus. Pronotum broadest across lateral angles, the side margins continuous with the curve of anterior margin, strongly curved in front, posterior margin broadly, slightly emarginate. Elytra rather long, coriaceous, obscuring the venation; venation of the same pattern as in *Tettigonia*, except that the apical cells are usually longer and narrower. Anterior tibiæ round or prismatic.

This genus was founded on a South American species (*variegata*) in which the head is very similar to that of *coccinea*, but the apex of the elytra is slightly emarginate in the middle and the outer cells very weak and obscure; the venation, however, is essentially the same as in *coccinea*, and the notch in the elytra, while distinct in a few species, is variable or wanting in others from the same region and appears to be a specific rather than a generic character.

KEY TO THE SPECIES.

A. **Vertex unmarked except for a black band on the anterior margin. Species robust 8 mm. or over.........*coccinea* Forst.**

AA. **Vertex with black markings nearly parallel with the anterior margin which is usually black lined, often a pair of approximate median lines on the disc. Smaller 6 mm. or under...... ....*versuta* Say.**

Diedrocephala coccinea Forst. Plate VI, Fig. 2.

Cicada coccinea Forst. Nov. Spp. Ins., p. 96. 1781.
Tettigonia quadrivittata Say. Jour. Acad. Nat. Sc. Phila. VI, p. 312. 1831.
Tettigonia picta Walk. Homop. III, p. 758, 1851.
Tettigonia teliformis Walk. Homop. III, p. 764, 1851.
Diedrocephala coccinea Osb. & Ball. Iowa Acad. Sc. IV. p. 177. 1897.
Tettigonia quadrivittata Fowl. Bio. Homop. II, p. 276. Pl. 18. Fig. 20, 1900.
Tettigonia idonea Fowl. Bio. Homop. II, p. 276, Pl. 18, Fig. 22, 1900.

Reddish with green stripes on pronotum and elytra. Vertex orange, black margined. Length, 8-9 mm.; width, 1.75 mm.

Vertex slightly convex except before the apex, slightly acutely angled, margins rounding to the acute apex, two-thirds the length of the pronotum. Face distinctly convex as seen from side, the front broad. Elytra long, narrow at the apex, the apical cells long and narrow—the second one especially so, outer anteapical cell acuminate anteriorly.

Color; face and vertex yellow, separated by a broad black band, striated just below the margin, a line on either side extending in on the suture, sometimes angled to the ocellus. Pronotum reddish, a narrow band on the anterior margin in the middle, a broad median stripe extending in from the posterior margin, connected behind with a pair of oblique stripes from the humeral angles, deep green. Scutellum yellow, impressed line often dark. Elytra red, the costal margin, the sutural margin before the middle, the claval suture and a median stripe on corium, green, the appendix black, legs and below yellow. The black margin to vertex continued across eye and under the margin of pronotum. Sometimes the vertex and scutellum are washed with red or the green stripes on pronotum coalesce leaving only a spot on either side of the disc, red.

Genitalia; female segment nearly twice as long as the preceding, posterior margin acutely rounding back to the lateral margins. Male plates long triangular, concavely attenuate, two-thirds the length of the pygofers nearly half longer than the ultimate segment.

Specimens have been examined from Ontario, New Hampshire, Vermont, New York, Connecticut, District of Columbia, Georgia, Alabama, Tennessee, Florida, Kentucky, Mississippi, Ohio, Illinois, Iowa, Michigan, Minnesota, Missouri, Nebraska and Kansas. It ranges from Canada and Maine to Florida, west to central Nebraska and Kansas, and south to Mississippi and Texas and on to Mexico and Central America.

DIEDROCEPHALA VERSUTA SAY. Plate VI, Figs. 3, 4, and 5.

This is another very variable species in color markings and somewhat so in form. Nearly all gradations between these three varieties will be found but the following key will readily place all the specimens examined in their correct variety.

A. A black band on anterior margin of vertex...... *versuta* Say.

AA. The anterior margin of vertex without a band, a black spot at apex.

B. A pair of black spots against eye in front sometimes wanting, a few fuscous arcs on margin but not reaching spot at apex....... ... . *lineiceps* Spin.

BB. Margin all pale except for spot at apex and one on each side near it..*cythura* Bak.

VAR. VERSUTA SAY. Plate VI, Fig. 3.

Tettigonia versuto, Say. Jour. Acad. Nat. Sc, Phila., p. 311, 1831.
Tettigonia redacta, Fowl. Bio. Homop. II, p. 276, pl. 18, fig. 21, 1900.

Resembling *coccinea* but smaller, reddish or yellowish, with definite lines on vertex and scutellum. Length, 5-6 mm.; width, 1.25 mm.

Vertex flat, except for posterior margin between the ocelli, nearly right angled the apex blunt, the lateral margins very slightly rounding, four-fifths the length of the pronotum. Face feebly convex, acutely angled with vertex. Elytra moderately long, venation as in *coccinea*, the outer anteapical cell sometimes broken up or wanting.

Color; vertex pale yellow, a black stripe just over the margin on front, a pair of slender, approximate, median lines which are joined anteriorly to a pair of broken lines just inside and almost parallel with the margins and running back inside the eyes, interrupted by the black sutures which inclose the ocelli. The space between these lines almost white. Pronotum, pale yellow in front, green behind. Scutellum yellow, three longitudinal stripes in front of the transverse suture and two behind; sometimes a pair of dots inside the basal angles. E ytra geen, the claval suture with a blue stripe, either side of which is a broader red one, the inner pair of stripes sometimes extending forward across the pronotum and converging on the vertex, apical margin and posterior third of costa pale, with numerous triangular spots. Face and below, pale yellow.

Genitalia; female segment nearly twice as long as the penultimate, the disc longitudinally elevated, posterior margin obtusely, angularly produced, the sides a little concave; male plates a little longer than the ultimate segment, concavely acuminate, their black tipped apices curving up around the pygofers, side margins with fine hairs.

Specimens of this form are at hand from the District of Columbia, Maryland, Virginia, North Carolina, Georgia, Florida, Ohio, Illinois, Kentucky, Tennessee, Alabama, Mississippi, Louisiana, Texas, and various parts of Central Mexico.

VAR LINEICEPS, SPIN. Plate VI, Fig. 4.

Tettigonia liniceps, Spin. Fauna Chilena, p. 283, 185-.

Form and size of variety *versuta* nearly. Vertex slightly shorter, blunter. Color green, vertex yellow, the marginal band reduced to three spots, one on apex and one against either eye. The stripe on either side just inside the margin, with a broad green margin behind, extending back to the oscelli. Scutellum orange yellow.

Elytra without the red stripes, and with but two or three black spots at tip. Sometimes the spots next the eye in front are wanting, and there are two or three fuscous arcs on the upper part of front, which leads to the next variety.

Specimens of this variety are at hand from Texas and Mexico. It was described from South America.

VAR CYTHURA, BAK. Pl. VI, Fig. 5.

Tettigonia cythura, Baker. Psyche VIII, p. 268, 1898.

Vertex slightly shorter than in the preceding variety. Slightly smaller.

Color; vertex and anterior part of pronotum pale yellow, the marginal band reduced to a spot at apex and a smaller one each side one-third the distance to the eyes, the lines inside the margin and dashes against the eye as in the typical form, median lines a little broader and shorter, often about five spots along the front margin of pronotum. Elytra bright green, red bands obsolete, blue ones pale, black spots at apex small or wanting, nervures slightly fuscous.

Specimens are at hand from California, and Lower California and Mexico, and Baker reports it from Arizona. This variety represents the same change in form and color for this species that is shown in the Mexican varieties of *occatoria*, and the same broadening and shortening of the vertex that is seen in the Mexican forms of *bifida* and *tripunctata* and the *confluens* form of *hieroglyphica*. Specimens of this form labeled *Tettigonia cythura*, Uhl., in Baker's handwriting are in the National Museum collection.

GENUS DRAECULACEPHALA NOV. GEN.

Similar to *Diedrocephala* the vertex usually longer and more acutely angled. Face, as seen from side, usually straight, or slightly concave to the middle of clypeus, where it is broken backwards. Disc of clypeus quite gibbous. Pronotum with the lateral margins parallel, narrower than or only equaling the eye. Elytra long, narrowing apically greenish, the nervures raised distinct, the apical and the anteapical cells irregularly reticulate veined. Anterior tibiae slender, round. Type of the genus *D mollipes*, Say.

This is quite distinctively a temperate region group, only a few of the forms extending very far southward. The reticulate venation, while only a trivial character, will at once distinguish the typical forms. The

larvæ of these forms show quite as much divergance from the general Tettigonia form as do the adults.

A. **Front, as seen from side, straight or concave above, clypeus definitely angled. Sides of front with numerous dark arcs.**

B. **Vertex long, acute, margins as seen from above straight, apex with minute spots or none. Profile of front straight. A pair of black stripes beneath the eyes in line with the margins of the elytra.**

C. **Vertex in the female longer than the pronotum, distinctly longer than broad. Lines on vertex rarely broad. Size small, male segment broad.......................................** ***mollipes*, Say.**

CC. **Vertex in female slightly shorter than pronotum, distinctly shorter than broad, face deep; lines on vertex broad, distinct. Size large, female 10 mm. or over. Male segment long, cylindrical ....** ***angulifera*, Walk.**

BB. **Vertex shorter, stouter, margins as seen from above slightly rounding, two dark spots on apex and another pair on margin against eye. Profile of front slightly rounding.**

C. **Vertex acutely angled, longer than pronotum in the female, the lines distinct, heavy; male vertex with a dark wedge back of the apex and a pair of oblique ovals on the disc. Spots at apex and against eye small............** ***manitobiana*, n. sp.**

CC. **Vertex scarcely less than a right angle, eyes much wider than pronotum, the lines on vertex pale, spots at apex and against eye large, black.........................** ***novaeboracensis*, Fitch.**

AA. **Front, as seen from side, slightly rounding. Clypeus rounding or weakly angled, front and vertex mottled with brown or unmarked, never lined.**

B. **Vertex acutely angled, longer or about equalling the pronotum, elytra with few coarse reticulations.**

C. **Vertex very acutely pointed, apex curved upwards, half longer than between ocelli, vertex evenly mottled. Length of male, 6.5 mm..** ***floridana*, n. sp.**

CC. **Vertex moderately acute, the apex blunt, rounding. No longer than the distance between ocelli, a triangular mark back of apex. Male 5 mm. or less ....** ***gillettei*, n. sp.**

BB. **Vertex right angled, shorter than the pronotum. Elytra with numerous fine reticulations ......** ***reticulata*, Sign.**

Draeculacephala mollipes Say. Pl. VII, Fig. 1.

Tettigonia mollipes, Say. Jour. Acad. Nat. Sc. Phila. VI., p. 312, 1831.
Tettigonia innotata, Walk. Homop. III, p. 770, 1851.
Tettigonia antica, Walk. Homop. III, p. 771, 1851.

Tettigonia producta, Walk. Homop. III, p. 772, 1851.
Tettigonia acuta, Walk. Homop. III, p. 773, 1851.
Acopsis viridis. Prov. Nat. Can., p. 352, 1872.
Diedrocephala mollipes, Osb. & Ball. Ia. Acad. Sc. IV, p. 176, 1897.
Tettigonia mollipes. Fowl. Bio. Homop. II, p. 273, Pl. 18, Fig. 15, 1900.
Aulacizes lineata, Fitch, MSS.

Bright green. Vertex pale yellow, narrowly lined with black, acutely triangular, longer than the pronotum. Length, ♀ 7.5 mm., ♂ 6 mm.; width, 1.5 mm.

Vertex acutely angular, produced, disc flat or concave, margin straight, somewhat variable in length, always distinctly longer than the pronotum, in the female, slightly longer or almost equaling it in the male. Face long, retreating in an acute angle, in profile straight to the clypeus which is transversely inflated and angled slightly with the front. Elytra long, coarsely reticulate from apex back to the forking of the outer branch of the first sector, nervures raised, distinct.

Color; vertex, straw yellow, eyes, ocelli, a median line, a pair of posteriorly divergent lines on the disc, three concentric arcs on reflexed portion of front on each side and a pair of dots at apex, fuscous. Anterior part of pronotum and scutellum pale green to yellow, disc of pronotum and elytra bright grass green, nervures pale green, costal and apical margins light. Face pale yellow, sometimes washed with fuscous, about nine pairs of brown arcs on sides of front. Legs and below pale yellow, sometimes washed with fuscous or brown, especially in the male, a black line running back beneath the eyes on either side above which the brown or fuscous never extends.

Genitalia; female segment with the posterior margin truncate, the middle half obtusely, angularly produced. Male valve short and broad, rounding, plates long acutely pointed, half longer than the ultimate segment, the margins with a few weak hairs.

Specimens of this widely distributed and variable species are at hand from Maine, Vermont, New Hampshire, Massachusetts, Connecticut, Ontario, New York, Maryland, District of Columbia, Virginia, Kentucky, Ohio, Illinois, Michigan, Tennessee, Florida, Mississippi, Texas, Minnesota, Iowa, Missouri, Nebraska, Kansas, Wyoming Colorado, New Mexico, Arizona, Vancouvers Island, California, Cuba, and various places in Mexico as far south as Vera Cruz, and the Biologia reports it from Central America, and Walker's *innotata*, the identification of which is in doubt, was from Brazil.

VAR 7-GUTTATA, WALK. Plate VII, Fig. 2.

Tettigonia guttata, Walk. Homop. III, p. 773, 1851

Similar to typical *mollipes* in form and structure, a black spot on the disc of vertex, a pair at the base, another pair just inside the basal angles of the scutellum, and sometimes a third pair on the pronotum.

Specimens of this variety are at hand from Florida, Mississippi and Mexico. Signoret considered this a distinct species and described it as with a longer head than *mollipes*. There is nothing in Walker's description to indicate this, and the spots on vertex and scutellum are about equally common in Var. *minor*. Many specimens of typical *mollipes* possess the spots on vertex at the base in the form of oblique lines, and some of them have trace of fuscous on the disc in place of the spot there.

VAR MINOR, WALK. Plate VII, Fig. 3.

Tettigonia minor, Walk. Homop. III p. 772, 1851.

Form and structure of typical *mollipes*, nearly, shorter and more robust. Vertex shorter, especially in the males, where it is shorter than the pronotum and with a strongly depressed disc. Length, ♀ 6.7 mm., ♂ 5 mm.

Color; bright green, the anterior part of pronotum and vertex pale yellow, often washed with green. The males usually have the frontal sutures, ocelli, and tip of vertex, dark, and any or all of the spots of the preceding variety may be present. Face and below from smoky brown in the females to black in some of the males.

Specimens that have been referred to this variety are at hand from Florida, Mississippi, Texas, Arizonia, California, and Mexico, and forms intermediate in structure, but with the black face from points as far north as New York. This is the commonest form in the Southern states along the Gulf, and in California and Mexico, while on the other hand the females from Vancouvers Island and Cuba have the longest heads seen.

DRAECULACEPHALA ANGULIFERA WALK. Plate VII, Fig. 4,

Tettigonia angulifera, Walk. Homop. III, p. 771, 1851.

Form and color of *mollipes*, nearly, much larger with a broader, shorter, heavier lined vertex. Length of ♀ 10-11 mm., ♂ 8 mm.; width, 2.5 mm.

Vertex broad, slightly sloping from the elevated pronotum, disc concave in front, the lateral margins straight, length slightly less

than the basal width or the length of the pronotum. Face in profile straight, deeper than in *mollipes*, clypeus larger and more strongly angled. Pronotum broad, side margins long. Elytra strong, venation as in *mollipes*.

Color; as in *mollipes*. Pronotum and elytra deeper green, the nervures paler. Lines on vertex broad and distinct, black lined, extending back of the eye and margining the reflexed portion of front half way to the apex, a line along the margin from the suture to the eye, curving in to form a spot on the disc inside the eye. Face pale yellow, about nine short arcs on the sides of front, a spot on genae and a dot on the outside the lorae, black. Below usually pale, a line running back from under the eye black, sometimes all below this line clouded with fuscous.

Genitalia; female segment with the posterior margin rounding, the apex slightly, angularly produced, pygofers long and narrow.

Male, ultimate segment longer than wide, cylindrical, from the open end of which appears a semi-circular valve and a pair of long, strong, slightly, divergent, pincer-like plates, longer than the long ultimate segment, their tips curving upwards and inwards.

Specimens have been examined from New York, Pennsylvania, Ohio and Iowa and Walker described it from New Foundland, and it has been reported from Canada and Kansas. The strikingly large size, especially of the female, will at once separate this species. The male genitalia is also very distinct.

DRAECULACEPHALA MANITOBIANA N. SP. Plate VII, Fig. 5.

Form of *novaeboracensis* nearly, with a longer head, as long as in *angulifera*, but much narrower. Color as in the latter species, the males often with a black wedge and a pair of ovals on disc of vertex. Length, ♀ 8-9 mm., ♂ 7-8 mm.; width, 2 mm.

Vertex one-fourth longer than the pronotum, as long as its basal width, disc flat the margins thick, slightly but distinctly rounding. Face moderately deep, profile convex or slightly angled before the clypeus, which is gibbous and gives a second angle to the profile. Pronotnm small, elytra and venation as in *mollipes*.

Color; deep green as in *angulifera*; vertex washed with green. Female with a light band around the broad margin of the vertex; inside of this on either side are five concentric lines, the rest of the markings as in *angulifera*. Spots at the apex rather large, separated by an elongate ivory white mark. Front with ten pairs of rather long arcs and a median line fuscous, a black mark above the antennae and a dot outside the lorae. The male has a large triangular spot behind the apex of vertex and the broadened lines on the disc, black, the lines often becoming confluent and forming an

oval around each ocellus, which is connected in front with the posterior angle of the triangle. Pronotum and elytra as in *angulifera*, much deeper green than in *novaeboracensis*, a black spot just under the margin of pronotum back of the eye.

Genitalia; female segment nearly truncate posteriorily with a triangular median production as in *mollipes*. Male ultimate segment nearly square, valve broad, obtusely triangular, plates thick, slightly divergent, roundingly triangular, their apices attenuate, curved up. Pygofers longer than the plates, keel shaped from below.

Described from eleven examples from Happy Hollow, North Park and Gunnison, Col., and a pair from Winnepeg, Manitoba. The longer head and heavier marking will at once separate this from *novaeboracensis*, to which it is allied structurally.

DRAECULACEPHALA NOVAEBORACENSIS Fitch., Pl. VII, Fig. 6.

Aulacizes novaeboracensis, Fitch. Homop. N. Y. St. Cab. p. 56, 1851.
Tettigonia prasina Walk. Homop. III, p. 768, 1851.
Diedrocephala mollipes Prov Pet. Faune Ent. Can. III, p. 266, 1889.
Diedrocephala novaeboracensis, Osb. & Ball. Ia. Acad. Sc. IV, p. 177, 1897.

Form of *manitobiana* head broader and shorter, wider than pronotum, a pair of black spots at apex and another pair against the eyes in front, the rest of the lines pale brown. Length, 8 mm.; width, nearly 2 mm.

Vertex in the female equalling the pronotum in length, distinctly shorter than its basal width, slightly less than right angled disc flat or a trifle convex margins thick and slightly rounded to the blunt point. Profile of front very slightly convex, not at all angled below, extending onto the clypeus which is angled above the middle. Pronotum rather short, elytra as in *manitobiana*.

Color; pale green, vertex pale lemon yellow, a pair of large triangular spots at the apex, separated by an ivory line, a pair of quadrangular ones on the margins in front of the eyes, the ocelli, and sometimes the sutures, black, remainder of the lines brown, somewhat obscure. Face pale yellow, arcs on front brown or fuscous often obscure, a large black spot above antennal sockets, a spot on genae, a dot outside lorae on either side, and often a dot on disc of clypeus, black. Disc of pronotum and elytra pea green, a black dot behind the eye below the margin of pronotum.

Genitalia; Female segment roundingly emarginate posteriorly with an obtuse median tooth. Male, valve large roundingly pointed a third the length of the plates, plates thick, finger-like, bluntly pointed, a little longer than the ultimate segment, a little shorter than appressed pygofers.

Specimens are at hand from Vermont, New York, Ontario, Iowa, Nebraska, Colorado, Idaho and Vancouvers Island,

and it has been reported from Maryland and Hudson's Bay (*prasina*). In this species the vertex and anterior part of pronotum are pale yellow, the lines on vertex obscure while the spots are distinct, while in the preceding species the vertex and anterior part of pronotum are washed with greenish and the lines are all dark and distinct.

DRAECULACEPHALA FLORIDANA N. SP. Plate VI, Fig. 6.

Resembling *mollipes* in size and length of head, the vertex slightly longer. the margin thicker, the apex acute conical, upturned. Front and vertex mottled with brown. Length of male, 6.5-7 mm.

Vertex acute conical, the lateral margins thick, one-fourth longer than the pronotum, disc concave anteriorly, front in profile broadly convex, the clypeus small, in the same curve. Pronotum as in *mollipes*, elytra similar to *reticulata*, but with fewer reticulations.

Color; front and vertex mottled with light brown and pale, a minute polished dot of light at the apex slightly margined with dark brown, a light median line ending in an irregular spot in front of the middle, the inner margin of the ocelli broadly white, frontal sutures with black lines to the ocelli. Pronotum pale the disc, omitting a median line, green. Elytra green, the margins and nervures pale.

Genitalia; male, ultimate segment nearly square, valve almost concealed, plates a little longer than the segment, attenuately pointed.

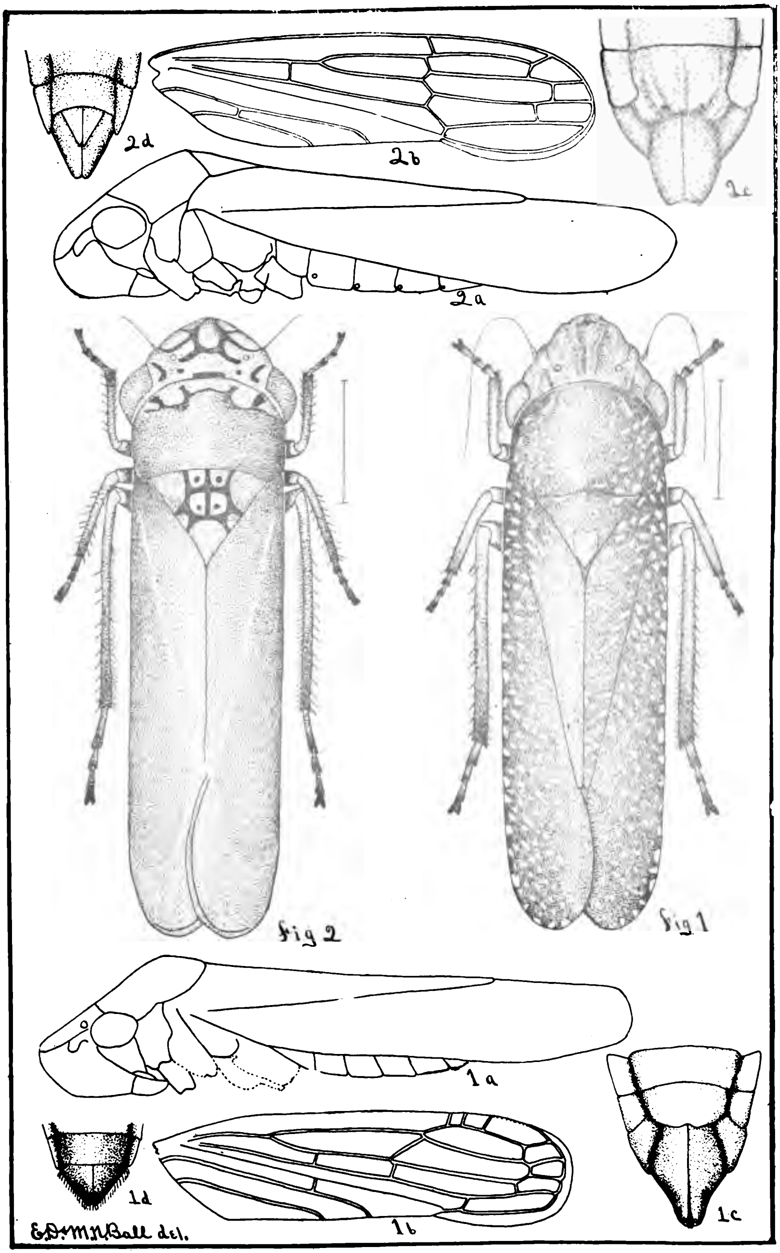
Described from two males from Charlotte Harbor, Florida, from the Iowa State College collection (Van. D. Coll.), through the kindness of Professor Summers.

The long, brown mottled, upturned vertex will at once distinguish this species.

DRAECULACEPHALA GILLETTEI N. SP. Plate VI, Fig. 7.

Intermediate in form and size between *floridana* and *reticulata*, somewhat stouter, vertex not quite as long as the pronotum. Color grayish cinereous, a dark wedge on vertex. Length, ♀ 6 mm., 5.25 ♂ mm.; width, 1.5 mm.

Vertex broad, slightly convex, apex blunt, not quite as long as the pronotum, lateral margins rounding to the convex front. Front in profile convex, lower part of clypeus rounding back from the curve of the front. Pronotum broad, slightly angularly emarginate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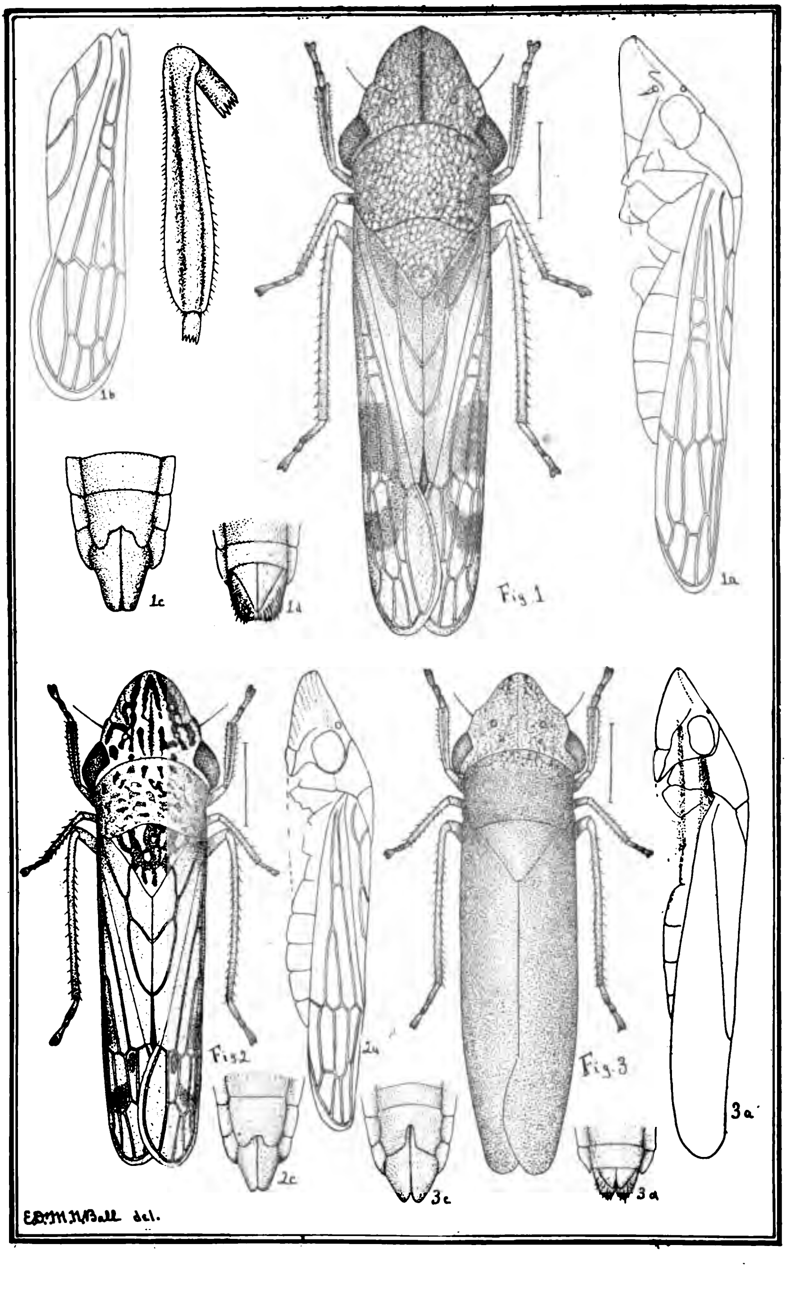
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E.D.M.H.Ball del.

in the middle posteriorly. Elytra rather broad, venation distinct, similar to that of *floridana;* female less reticulate.

Color; vertex and face pale yellow, finely irrorate with brown, the frontal sutures including the ocelli, a basal median line and an irregular wedge on anterior half, fuscous. Pronotum olive grayish, a row of submarginal creamy spots sometimes extending back onto the disc as pale lines. Scutellum pale impressed line, spots inside basal angles and a pair on anterior disc, dark. Elytra cinereous or sometimes greenish, nervures pale. The male sometimes darkened up to a slaty brown. Below pale, margins of abdomen often red.

Genitalia; female segment half longer than the penultimate, posterior margin nearly truncate, a somewhat variable obtuse, median tooth. Male valve almost concealed, plates stout, coriaceous, scarcely longer than the ultimate segment, their apices bluntly pointed, upturned, whole genitalia reddish.

Described from eighteen specimens from La Salle and Fort Collins, Col. The first specimens were collected by Professor Gillette.

DRAECULACEPHALA RETICULATA SIGN. Plate VI, Fig. 8.

Tettigonia reticulata. Sign. An. Ent. Soc. Fr., p. 22, Pl 2, Fig. 10, 1854.
Diedrocephala flaviceps, Riley. Amer. Ent. III, p. 78, 1880.
Tettigonia diducta, Fowl. Bio. Homop II, p. 274, Pl. 18, Fig. 17, 1900.
Helachara fulvicephala, Fitch MSS.

Small, moderately stout, vertex blunt, shorter than pronotum. Elytra densely reticulated before the apex. Green with the head pale, washed with reddish. Length, ♀ 5.5 mm., ♂ 4-5 mm.

Vertex bluntly conical, nearly right angled, two-thirds the length of the pronotum, ocelli large. Face in profile convex. The clypeus slightly elevated, front broad rounding with the vertex. Pronotum rather long, strongly emarginate on the median third posteriorly. Elytra as in *mollipes*, but with the reticulations more numerous, much more numerous than in the two preceding species.

Color; vertex and face pale, finely irrorate with brown and washed with reddish orange, a pair of spots against the ocelli on the inside and a marginal line sometimes emphasized in the spots at the apex, creamy; ocelli shining black; anterior margin of pronotum and the scutellum pale yellow; disc of pronotum and elytra green or grayish green; nervures and margin pale, distinct. Legs and below pale yellow, margins of the abdominal sternites in the female reddish.

Genitalia; female segment half longer than the penultimate, posterior margin truncate, the median half roundingly produced. Male valve short, nearly as wide as the plates at base, plates long, acutely triangular, slightly longer than the ultimate segment.

Specimens are at hand from South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas, California, and Mexico, and it was described from Cuba.

Signoret's description is very good, and fits our species in every particular except that he gives the length as 3 mm.; this would be too small, but the length line on the plate is fully 4 mm., which would fit the males of this species, and they also more often possess the "three white points at the apex," which he describes.

EXPLANATION OF PLATES.

The figures on a plate, except where otherwise noted, are drawn to the same scale.

The drawings were made by my wife from my pencil sketches and under constant supervision as regards structural accuracy.

PLATE I.

Fig. 1.—*Aulacizes irrorata*. **Female, typical form.**
a, profile; *b*, elytron; *c*, ♀ genitalia; *d*, ♂ genitalia.

Fig. 2.—*Oncometopia undata*. **Female, typical form.**
a, profile; *b*, elytron; *c*, ♀ genitalia; *d*, ♂ genitalia.

PLATE II.

Fig. 1.—*Homalodisca triquetara*. **Female, typical.**
a, profile; *b*, elytron; *c*, ♀ genitalia; *d*, ♂ genitalia.

Fig. 2.—*Homalodisca liturata*. **Female.**
a, profile; *b*, elytron; *c*, ♀ genitalia.

Fig. 3.—Head and etc., of *Homalodisca insolita*. **Female.**
a, profile; *c*, ♀ genitalia; *d*, ♂ genitalia.

PLATE III.

Fig. 1.—*Tettigonia hieroglyphica*. **Typical form from Iowa.**
a, profile; *b*, elytron; *c*, ♀ genitalia; *d*, ♂ genitalia.

Fig. 2.—Variety *dolobrata* from Iowa.

Fig. 3.—Head, etc., of variety *uhleri* from Col.
k, variety *uhleri* from Washington showing long elytra.

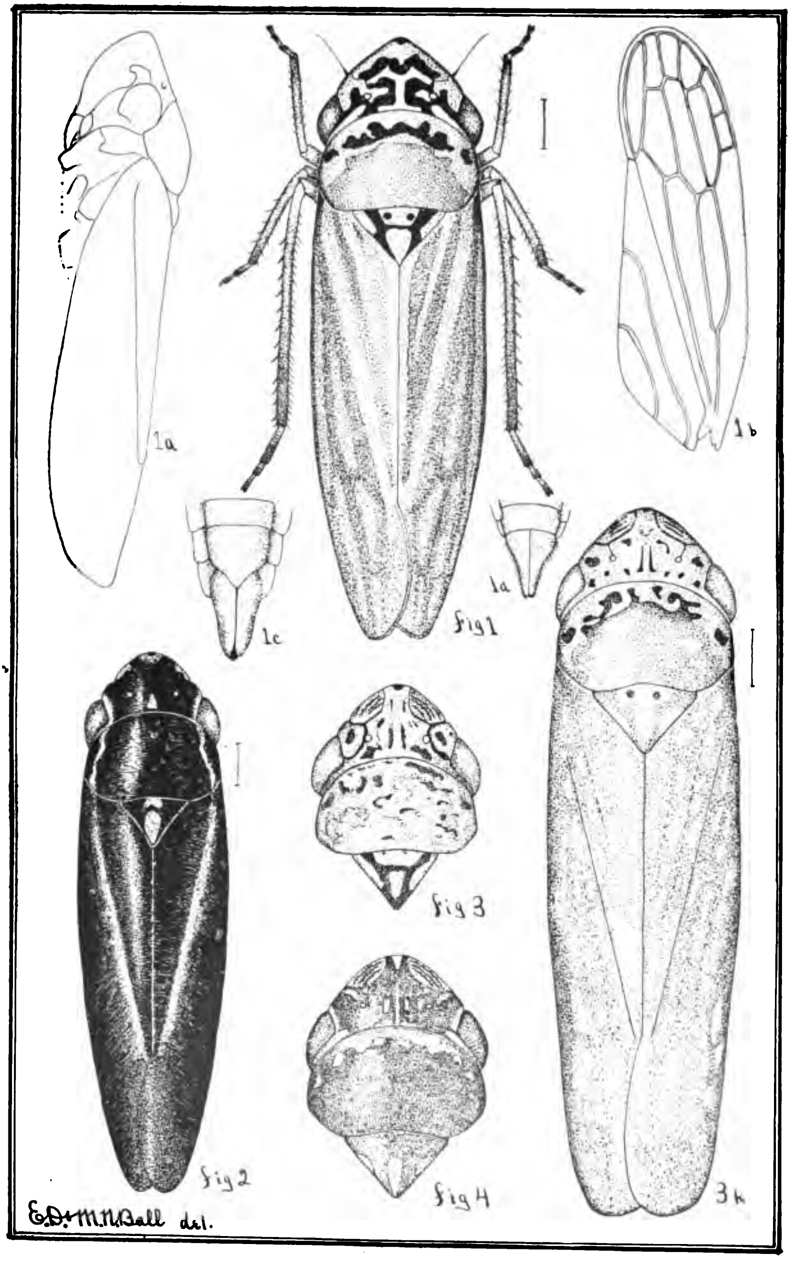
Fig. 4.—Head, etc., of variety *confluens* from Washington.

PLATE IV.

Fig. 1.—*Tettigonia gothica*. **Typical markings.**
a, profile; *b*, elytron; *c*, ♀ genitalia; *d* ♂ genitalia; *e*, face; *k*, head, etc., of same with light markings.

Fig. 2.—Head, etc., of *Tettigonia atropunctata* from California.
c, ♀ genitalia; *d*, ♂ genitalia.

Fig. 3—Head, etc , of *Tettigonia dohrni* from Arizona.
c, ♀ genitalia; *d*, ♂ genitalia.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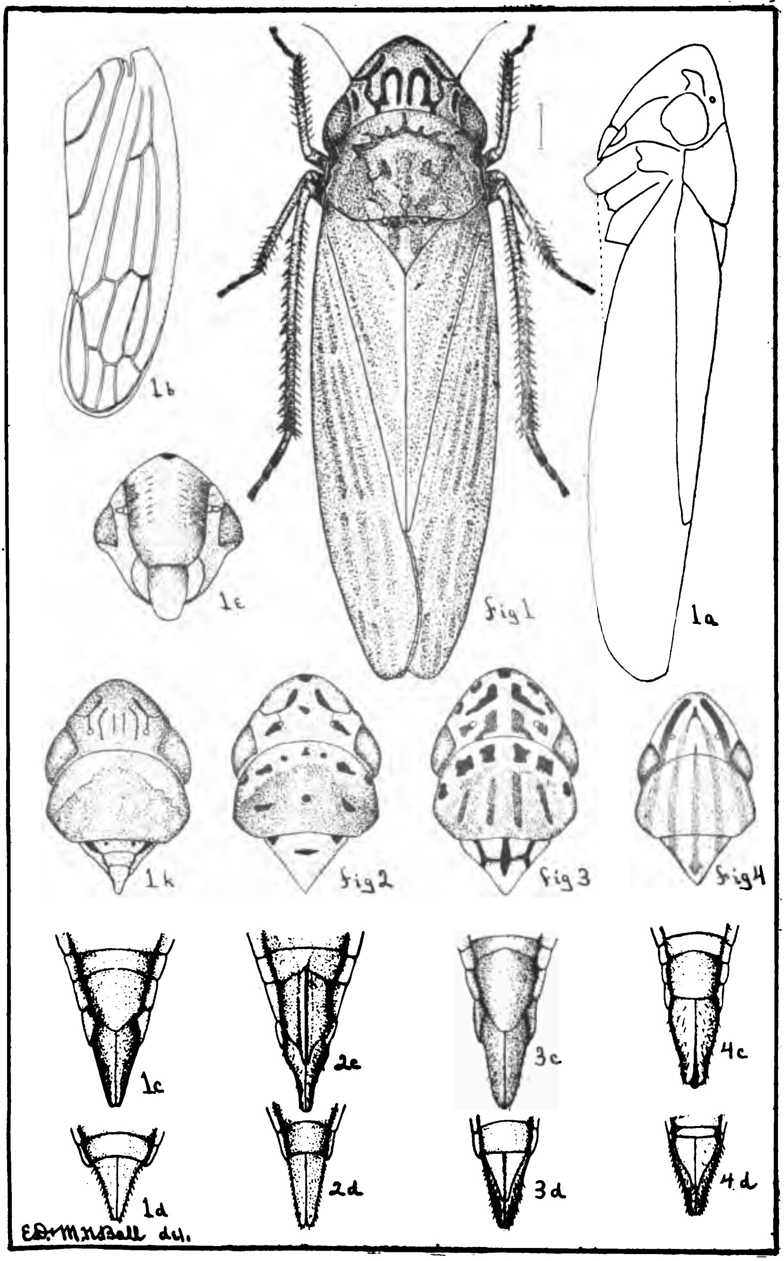
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E.D. McBall del.

Fig. 4.—Head, etc., of *Tettigonia occatoria* from Mississippi.

The figures on the lower half of the plate are drawn to a smaller scale than those on the upper.

PLATE V.

Fig. 1.—*Tettigonia bifida*. Female.
a, profile; *b*, elytron; *c*, ♀ genitalia; *d*, ♂ genitalia.

Fig. 2.—Head, etc., of *Tettigonia geometrica*.
b, elytron.

Fig. 3.—*Tettigonia tripunctata*.
a, profile; *b*, elytron; *c*, ♀ genitalia; *d*, ♂ genitalia.

Fig. 4.—*Tettigonia hartii*. Female from Ohio.
a, profile; *b*, elytron; *c* ♀ genitalia; *d*, ♂ genitalia.
e, Male of same from Ohio.

PLATE VI.

Fig. 1—Head, etc., of *Helochara communis*.
a, profile; *c*, ♀ genitalia; *d*, ♂ genitalia; *e*, antenna (enlarged).

Fig. 2.—Head, etc., of *Diedrocephala coccinea*.
a, profile; *b*, elytron (reduced); *c*. ♀ genitalia; *d*, ♂ genitalia.

Fig. 3.—Head, etc., of *Diedrocephala versuta*. Typical form from Tennessee.

Fig. 4.—Head, etc., of *D. versuta*, var. *lineiceps* from Texas.

Fig. 5.—Head, etc., of *D. versuta*, var. *cythura* from California.

Fig. 6.—Head, etc., of *Draeculacephala floridana* from Florida.
d, ♂ genitalia.

Fig. 7.—*Draeculacephala gillettei*. Female, Colorado.
a, profile; *b*, elytron; *c*, ♀ genitalia; *d*, ♂ genitalia.

Fig. 8.—Head, etc., of *Draeculacephala reticulata*.
d, ♂ genitalia.

PLATE VII.

Fig. 1.—Head, etc., of *Draeculacephala mollipes*. Female from Iowa.
a, profile; *b*, elytron; *c*, ♀ genitalia; *d*, ♂ genitalia.
k, Head, etc., of male of same.

Fig. 2.—Head, etc., of *D. mollipes*, var. *7-guttata*. Female from Florida.
k, Head, etc., of male of same from Mississippi.

Fig. 3.—Head, etc., of *D. mollipes*, var. *minor*. Female from California.
k, Head, etc., of male of same from Mexico.

Fig. 4—Head, etc., of *Draeculacephala angulifera*. Female from Iowa.
a, profile; *d*, ♂ genitalia.
k, Head, etc., of male of same from Iowa.

Fig. 5.—Head, etc., of *Draeculacephala manitobiana*, Female from Colo.
a, profile; *d*, ♂ genitalia.
k, Head, etc., of male of same from Colorado.

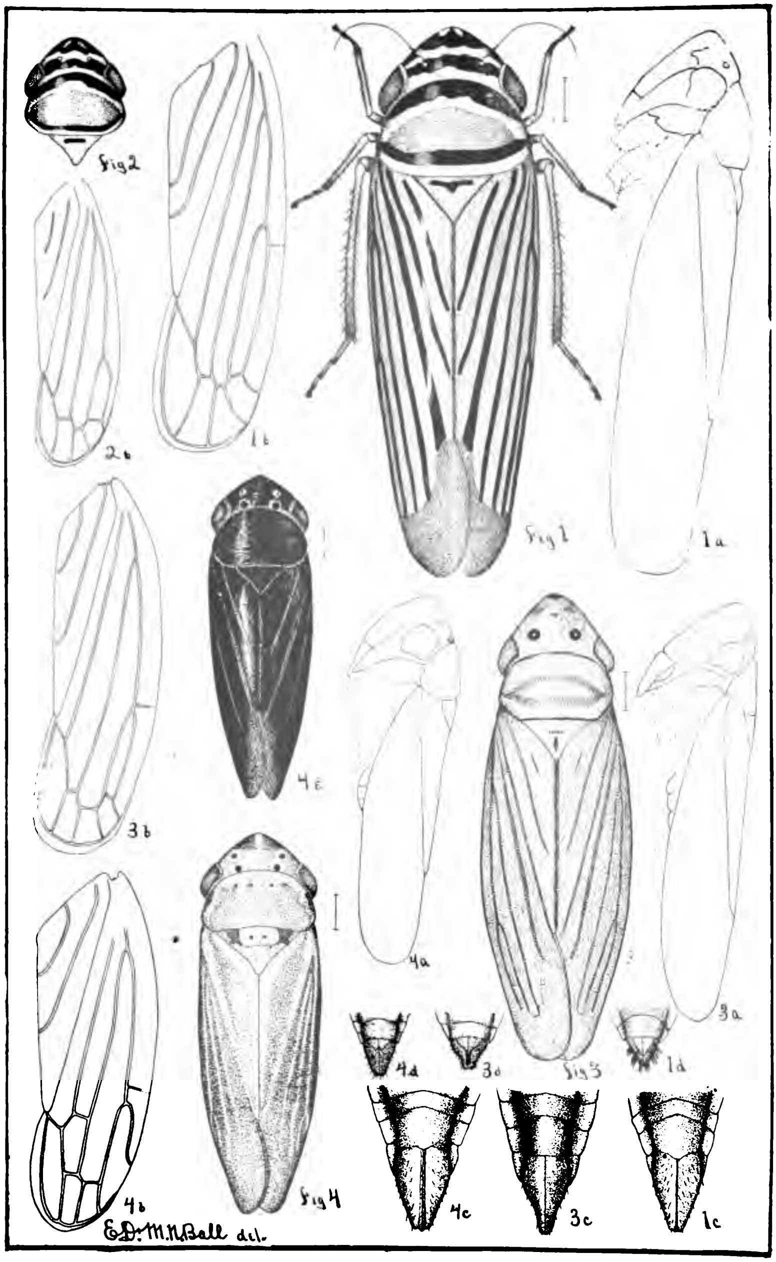
Fig. 6.—Head, etc., of *Draeculacephala novaeboracensis*. Female from Iowa.
a, profile; *d*, ♂ genitalia.
k, Head, etc., of male of same from Iowa.

THE MORPHOLOGY AND FUNCTION OF THE AMPHIBIAN EAR.

BY H. W. NORRIS.

In the struggle for existence as individuals the Amphibians, or Batrachians, seem to have a minor position. For the most part of insignificant size, with poorly protected bodies, and with retiring and inoffensive habits, these forms which we know as toads, frogs and salamanders, seem to be poorly adapted to maintain their species. From what the paleontologist tells us, we may well believe that the Amphibians as a class arose, flourished, and then declined to their present insignificant proportions long ago. It is because of the relationships of this group that it is of profound interest to science. It forms a connecting link, or rather a series of connecting links between the strictly aquatic Vertebrates, the Fishes, and the terrestrial forms. Presenting two distinct phases, a larval aquatic and an adult terrestrial condition, it presents for our observation the actual evolution of an aquatic, branchiate form into a terrestrial pulmonate form. Furthermore some forms retain the branchial organs throughout life, while others hardly give us a hint of a much shortened aquatic stage. This metamorphosis is not merely superficial, but is accompanied by profound morphological and functional changes.

Experiments carried on in recent years, notably by Professor F. S. Lee, have made it very probable that the ear in Fishes is not an organ of hearing, but rather an organ of equilibration. That it has this latter function in all Vertebrates is very well known. It is then in the Amphibia that the ear changes from an organ of equilibration alone to an organ of hearing, for it is certainly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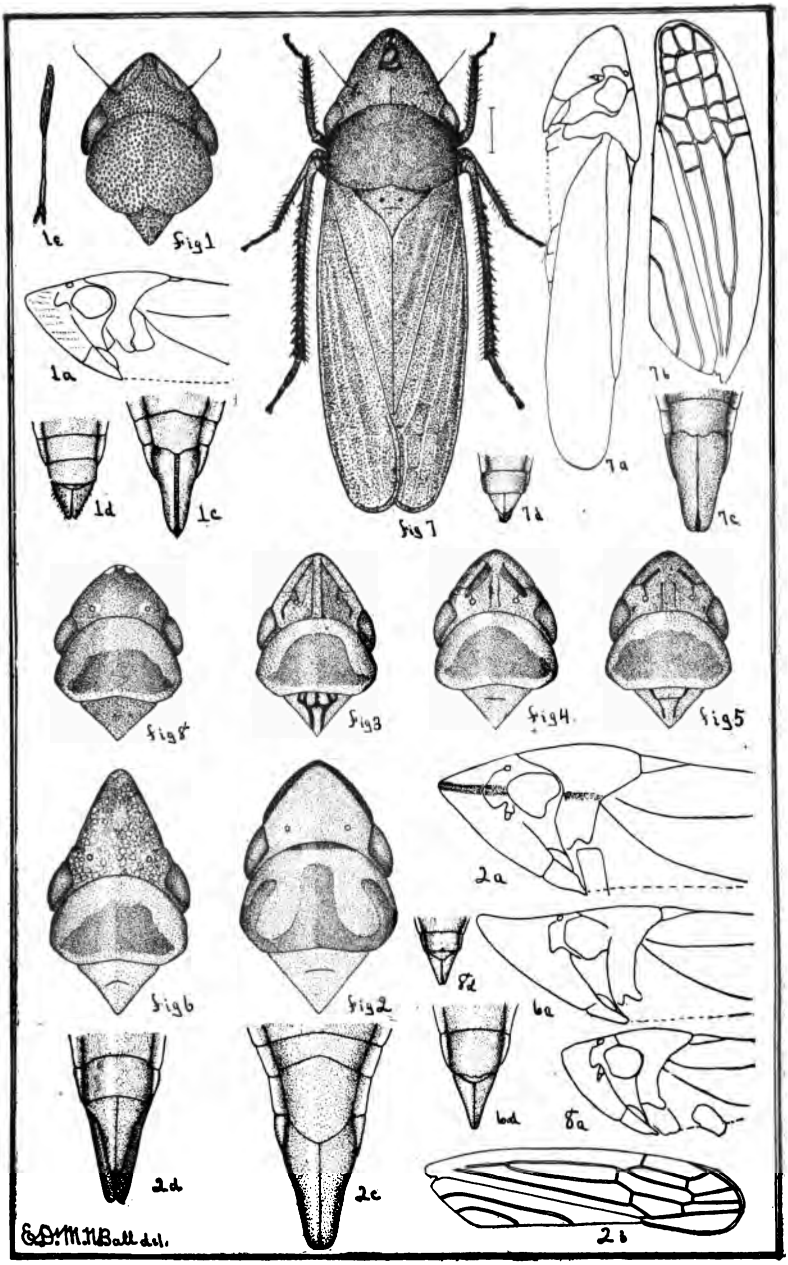
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6a
6d
8a
2d
2c
2b
E.D. & M.N.Ball del.

true that many of the toads and frogs have very acute auditory powers. We are not able to show experimentally whether there are any Amphibians in which the sense of hearing is wanting, since the bony skull and the small size of the ear capsule almost preclude the possibility of accurate experiments such as have been performed upon the Dog-fish. But we are justified, it seems to me, in basing some conclusions on the study of the structure of the Amphibian ear.

In the general form and relationships of its parts the inner ear, or labyrinth, of Amphibia, is essentially fish-like. The only important new structures are the pars basilaris, and closely associated with it the perilymphatic canal, the two structures that combine in the higher classes of Vertebrates to form that complicated organ, the cochlea. In Proteus, Necturus, Siren, Amphiuma, and presumably in that blind branchiate form, Typhlomolge, from the subterranean streams in Texas, the pars basilaris is wanting. In all other Amphibia, as far as investigation has gone, it is present. In the Urodela, with the exception of Amphiuma, in which it is absent, it is a small insignificant recess in the lagena and contains a small sense-organ. In the Anura it becomes a distinct part of the labyrinth with a well developed sense-organ, closely related to the perilymphatic canal. In the Anurous Amphibia there also occurs a well developed middle ear, or tympanum, a structure entirely wanting in the other members of the class and in the Fishes.

Is the ear in the tailed amphibians an organ of hearing? This cannot as yet be answered very satisfactorily. A distinct vocalizing apparatus is lacking in all but the Anurous Amphibia. Salamanders are notably silent creatures. John Burroughs, I believe, says that the Red Eft, that immature terrestrial form of *Diemyctylus viridescens*, produces a musical sound, but it is undoubtedly not a true vocalization. This lack of vocalizing powers in the Salamanders makes it very probable that they are defective in hearing. There being no tympanum present the ear covered up by bone and muscle, cannot well respond to

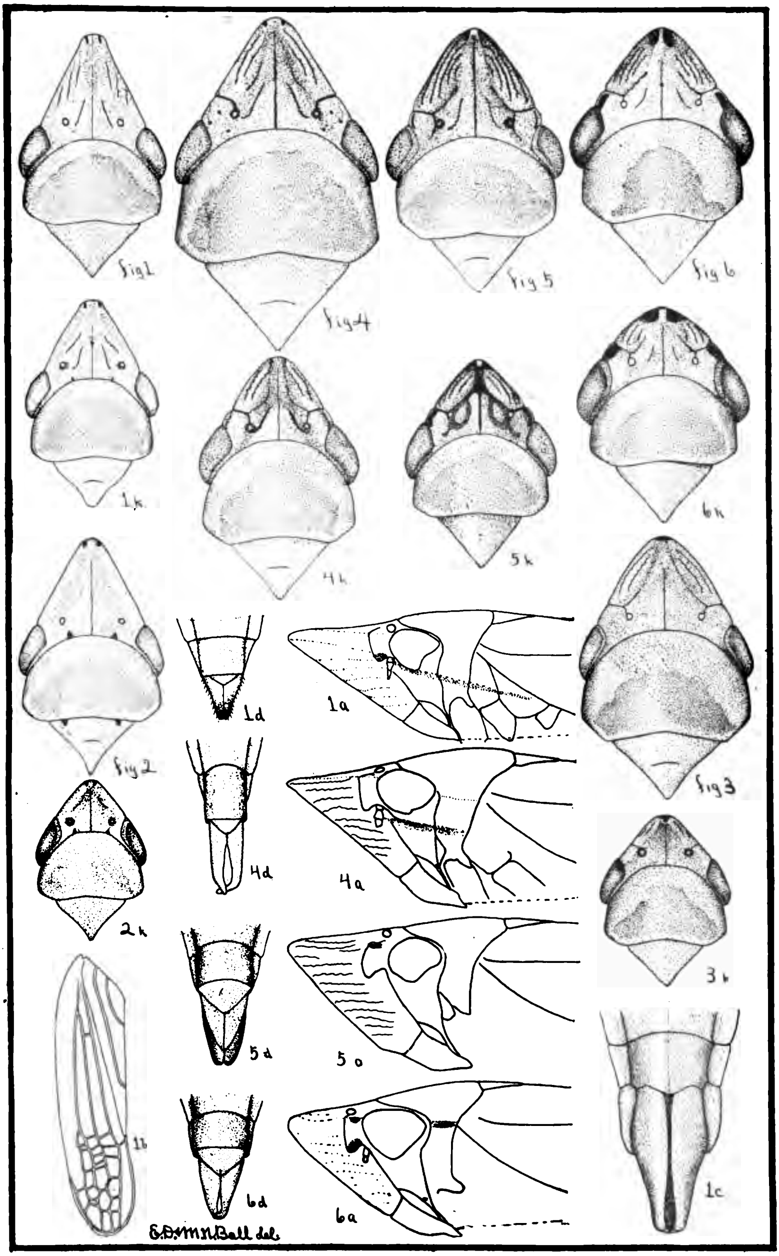
auditory stimulation. But the most significant fact, it seems to me, is that the pars basilaris is either absent or very imperfectly developed. This structure which finally evolves into the cochlea of the higher Vertebrates, is distinctively the organ of hearing, according to recent physiological interpretation.

We then, in all probability see in this transition class of Vertebrates, the Amphibia, the origin of an organ of hearing from an organ of equilibration, which latter function is always retained. To be sure it may be suggested that the lack of a pars basilaris in Proteus, Necturus, etc., may be due to degeneration. Admitting this possibility, yet as I have elsewhere shown, in the development of the ear of the Salamander, *Amblystoma*, the pars basilaris is the last of the parts of the labyrinth to be differentiated, and then only near the close of the larval period. That is, the order in which this structure appears in the embryo, undoubtedly corresponds to the way in which it originated in the Amphibians as they were evolving from the ancestral aquatic condition into the semi-terrestrial state of existing species.

A COMBINATION OF CHROMIC ACID, ACETIC ACID AND FORMALIN AS A FIXATIVE FOR ANIMAL TISSUES.

H. W. NORRIS.

That many of the fixing reagents in common use in the preparation of tissues for histological study are poorly adapted to the fixation of the ova and embryos of Amphibians, is evident to any one who gives more than casual attention to the matter. The large amount of yolk present in the cells of the Amphibian embryo makes completely uniform fixation with some reagents impossible, and then, too, the disintegrating effect of many fixing fluids upon the yoke granules makes the result very unsatisfactory. A fluid that gives good fixation is likely to interfere with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1c
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6a
E.D. Wm. Ball del.

subsequent staining, as witness most of the chromic acid and osmic acid compounds.

Some years ago I experimented on the eggs of *Amblystoma* with many of the fixing fluids commonly used by cytologists. I used also a fluid recommended in the fourth edition of Lee's Microtomist's Vade-Mecum, having the formula:

Chromic Acid 2 per cent 64 parts.
Glacial Acetic Acid 4 parts.
Formalin, Commercial, 32 parts.

At an early stage in the experimentation all fixing fluids containing osmic acid and platinic chloride were discarded, not only because of their imperfect penetration, and on the part of osmic acid great blackening power, but also because of their gelatinizing properties, causing the embryos to adhere so firmly to the glass dishes containing them that mutilation resulted on removing them.

On sectioning the embryos I was surprised to find that those fixed in the chromo-acetic-formalin mixture and stained *in toto* in Czoker's alum cochineal showed Karyokinetic figures in abundance and with great distinctness. None of the other fluids used approached it in faithfulness of preserving details.

To determine the contracting or swelling effects of various fixing fluids, eggs of *Amblystoma tigrinum* near the end of gastrulation were used. At this stage the egg is a nearly perfect sphere, containing a large cavity eccentrically situated, so that one side of the egg is very thin-walled. In this condition the embryo is very susceptible to the shrinking or swelling effects of reagents. Eggs, all in the same stage of development, were measured, and then fixed and hardened for several hours, and finally measured a second time. The following were the changes in diameter according to the fixing fluid used:

In Perenyi's fluid, 7½ per cent increase; in Kleinenberg's fluid, 5 per cent decrease; in picric acid alcohol (0.2 per cent in 50 per cent alcohol) 3½ per cent decrease; in formalin-alcohol (commercial formalin 2 per cent 4 parts, 95 per cent alcohol 6 parts) 3½ per cent increase; in 4 per cent

commercial formalin $10\frac{1}{2}$ per cent increase; in the chromo-acetic-formalin mixture no change in diameter.

In fixing mammalian tissues chromo-acetic-formalin gives good results, in some tissues better results than I have been able to obtain with any other fixing fluid. It seems to be especially good for glands and mucous epithelium. I have not obtained satisfactory results in treating nervous tissue with it. In the fifth edition of the Vade-Mecum Lee suppresses the formula for this fixing fluid, and concludes that his previous good results with it were accidental. I cannot agree with him.

In two or three days after being prepared the fluid changes from the chromic acid brown color to a chrome alum blue, due to the reduction of the chromic acid to chromic oxide. At the same time some of the formalin is oxidized to formic acid. Before these changes take place I find that the fluid has the characteristic defects of chromic acid; that is, the fixation and general preservation is not uniform, and staining is rather difficult. After six months standing the fluid does not appear to deteriorate.

The length of time required for fixation depends upon the size of the object. I have not observed any indication of bad results after treatment of 24–48 hours. Fixation should be followed by thorough washing in water, but the latter process is not necessarily so prolonged as when chromic acid alone is used. The formalin itself being such a good preservative one is allowed considerable latitude in the time of hardening.

Living embryos in which the muscular system is far enough developed te be functional are likely to become distorted when killed in the chromo-acetic-formalin. My custom has been to allow them to die slowly in chromo-acetic acid (chromic acid 0.2 per cent, acetic acid 0.1 per cent). This they do retaining their natural shapes. As soon as dead they are transferred to the chromo-acetic-formalin mixture.

NOTE ON THE TIME OF SEXUAL MATURITY IN CERTAIN UNIOS.

BY H. M. KELLY.

In the course of a recent study* of the parasites of the Unionidæ, the following data in regard to the time of sexual maturity in certain species, and their method of carrying their glochidia, were obtained. This primary inquiry involved the microscopical examination of the sexual glands of each individual. And in females whose gills were found swollen with the sexual product, the portion of these organs forming the marsupium and the stage of development of its contents, were also noted.

The examinations were made at three seasonal periods: (1) in the latter part of April and through the month of May; (2) through July and the first half of August; (3) through October and in early November. It is unfornate that the two gaps thus made—the month of June, and the latter part of August and all of September—occur well within the limits of the times of sexual activity. This, with the comparative scantiness of material in certain species, at the critical period, has reduced the value of the observations. Where, however, blanks occur in the following tabulation, it is often not difficult to infer the condition from either the state of the other sex at that time, or from the result of later examinations of the same sex.

With the exceptions noted below, the Unios examined are from the vicinity of Havana, Illinois, and Mount Vernon, Iowa, and of species common to the two regions. Data from *Unio-complanatus*,† *Alasmodonta marginata*,

* H. M. Kel y, '99. Bull. Ill. State Lab. Nat. Hist., Vol V., Art. VIII. "A Statistical Study of the Parasites of the Unionidæ."

† Those who are not acquainted with Simpson's recent classification of the Unionidæ used herein, will find no difficulty in connecting these names with those previously in common use. The specific names with proper inflectional endings remain the same, except that Unio cornutus becomes Obliquaria reflexa. The genera Quadrula, Unio, Obliquaria, Plagiola and Lampsilis are divisions of the former genus Unio, Alasmodonta is synonomous with former Margінata, and Strophitus has been removed from Anodonta.

undulata, and *tappaniana*, and *Lampsilis nasutus* and *ochraceus* from Pennsylvania waters are included. Two of these examinations, as indicated in the accompanying tables, occurred in September.

Table I. shows the distribution of the material examined by species, sex, and time of observation. In addition to the fourteen hundred and ninety-eight included, thirty-one were excluded because the determination of sex was impossible through infestation of the sexual organs by parasitic cercaria to the utter atrophy of the germinal tissue. A single individual of *Q. trigona* was hermaphrodite.

Table II. exhibiting the findings, is largely self-explanatory. The similarity of the closely related forms, in their time of maturity and method of carrying the young, is apparent. Because in certain species, the old glochidia are found still in the marsupium when examined in May, it is inferred that in these cases they have been carried through the preceding winter.

Furthermore, though this is not shown in the tabulations, for the reason that in most species throughout the time of sexual maturity a sufficient number of both sexes are in a condition plainly unripe, and because of the absence of the glochidia and swollen gills containing them in certain females, when others of their species are normally gravid, it is believed that the period of sexual maturity does not always recur every year.

TABLE I. SEASONAL AND SEXUAL DISTRIBUTION OF MATERIAL.

SPECIES	April		May		July		Aug.		Sept.		Oct.		Nov.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F	M.	F.
Quadrula multiplicata Lea	----	----	----	----	16	8	---	----	----	----	----	----	----	----
Quadrula tuberculata Bar	----	----	1	1	20	14	2	----	----	----	----	----	----	----
Quadrula metanevra Raf	----	----	15	13	....	2	----	----	----	----	2	3	----	----
Quadrula lachrymosa Lea	----	----	----	--	14	13	----	----	----	---	----	----	----	----
Quadrula asperrima Lea	----	---	----	----	6	15	---	----	----	----	---	----	----	----
Quadrula pustulata Lea	..	----	---	---	4	6	4	6	..	----	----	----	----	----
Quadrula pustulosa Lea	----	----	14	9	39	17	---	----	----	----	2	3	----	----
Quadrula plicata Say	..	----	7	11	10	32	----	----	---	----	4	8	----	----
Quadrula trigona Lea	----	----	----	----	4	6	5	10	....	----	----	----	----	----
Quadrula rubiginosa Lea	----	----	14	17	12	----	----	----	----	----	5	2	----	----
Quadrula ebena Lea	----	----	----	----	3	6	10	12	...	----	----	----	----	----
Unio gibbosus Bar	----	----	----	----	18	9	3	3	----	----	----	----	----	----
Unio complanatus Sol	----	----	----	----	36	29	43	27	----	----	----	----	----	----
Alasmodonta confragosa Say	----	----	---	----	13	9	4	----	----	----	----	----	---	----
Alasmodonta companata Bar	----	----	13	12	6	7	2	3	----	----	5	6	3	4
Alasmodonta rugosa Bar	----	----	1	----	---	1	----	----	----	---	6	1	5	3
Alasmodonta marginata Say	----	---	---	---	----	----	16	20	6	6	1	----	----	----
Alasmodonta undulata Say	----	----	----	---	----	----	----	----	2	1	----	----	----	--
Alasmodonta tappaniana Lea	----	----	----	----	---	1	----	----	----	----	----	---	----	----
Strophitus edentulus Lea	----	----	4	4	2	4	2	1	----	----	2	2	1	2
Anodonta imbecilis Say	----	----	----	--	3	37	----	----	----	----	----	3	----	----
Anodonta suborbiculata Say	----	----	----	----	18	2	----	----	----	----	----	----	----	----
Anodonta grandis Lea	---	----	----	---	2	1	----	----	----	----	----	2	2	1
Anodonta corpulenta Coop	--	----	6	2	18	11	6	3	----	----	----	----	----	----
Obliquaria reflexa Raf	----	----	1	3	14	6	----	----	----	---	1	----	----	----
Plagiola securis Lea	----	---	----	----	5	----	----		..	---	----	----	----	----
Plagiola elegans Lea	--	----	8	12	14	8	----	----	----	----	---	----	----	----
Plagiola donaciformis Lea	----	--	5	7	18	4	..	---	----	----	----	----	----	----
Lampsilis parvus Bar	----	----	----	6	----	25	---	---	----	----	----	----	----	....
Lampsilis ellipsis Lea	----	----	3	2	2	1	---	----	----	----	3	2	1	----
Lampsilis ligamentinus Lam	----	----	4	5	6	3	8	4	----	----	24	21	---	----
Lampsilis luteolus Lam	----	----	..	---	3	6	6	8	----	---	----	---	1	----
Lampsilis nasutus Say	---	...	....	----	---	----	2	2	---	----	---	----	---	----
Lampsilis anodontoides Lea	---	----	4	2	11	32	---	--	----	----	1	1	1	----
Lampsilis rectus Lam	---	----	8	10	6	3	1	----	----	---	6	5	4	2
Lampsilis ochraceous Say	---	----	----		---	----	---	1	----	----	---	----	----	----
Lampsilis ventricosus Bar	3	7	8	7	28	9	6	4	..	----	19	19	----	----
Lampsilis alatus Say	1	2	4	4	23	9	---	---	----	----	3	3	1	----
Lampsilis laevissimus Lea	----	----	---	---	3	----	1	----	----	---	----	---	----	..
Lampsilis gracilis Bar		--	15	3	23	20	11	11	.	----	6	2	3	2

TABLE II. SEXUAL CONDITION.

SPECIES	Sperm Ripe in	Ova Ripe in	Gills Filling in	Portion of Gills Occupied by Marsupium	Old Glochidia Found in
Quadrula multiplicata					
Quadrula tuberculata	July				
Quadrula metanevra	May	May			
Quadrula lachrymosa	July	July			
Quadrula asperrima	July	July			
Quadrula pustulata	July	July			
Quadrula pustulosa	May, July Oct	July			
Quadrula plicata	July	July	July	Whole, all four	
Quadrula trigona	July	July	July	Whole, all four	
Quadrula rubiginosa	May, July.	May	May	Whole, all four	
Quadrula ebena	July	July	July, Aug.	Whole, all four	
Unio gibbosus	July	July	July, Aug.	Whole outer pair	
Unio complanatus	July, Aug.	July, Aug.	Aug	Whole outer pair	
Alasmodonta confragosa		July			
Alasmod'nta complanata				Whole outer pair	Nov., May
Alasmodonta rugosa				Whole outer pair	Nov.
Alasmodonta marginata	Aug		Aug	Whole outer pair	Sept.
Alasmodonta undulata				Whole outer pair	Sept.
Alasmodonta tappaniana			July	Whole outer pair	
Strophitus edentulus			Aug	Whole outer pair	Oct. Nov. May
Anodonta imbecilis		July	July	Whole outer pair	Oct.
Anodonta suborbiculata					
Anodonta grandis			July	Whole outer pair	Oct., Nov.
Anodonta corpulenta				Whole outer pair	May
Obliquaria reflexa	May, July.	May, July.	July	Post. part, outer pair	Nov.
Plagiola securis	July				
Plagiola elegans	May	May	May, July.	Post. part, outer pair	
Plagiola donaciformis	May, July.	May, July	May, July.	Post. part, outer pair	
Lampsilis parvus		May, July	May, July.	Post. part, outer pair	
Lampsilis ellipsis	July			Post. part, outer pair	Oct.
Lampsilis ligamentinus	July, Aug.	July, Aug	Aug	Post. part, outer pair	Nov.
Lampsilis luteolus	July	July	July, Aug.	Post. part, outer pair	
Lampsilis nasutus	Aug		Aug	Post. part, outer pair	
Lampsilis anodontoides	July		July	Post. part, outer pair	Oct., May
Lampsilis rectus	July			Post. part, outer pair	Oct., Nov. May
Lampsilis ochraceus			Aug	Post. part, outer pair	
Lampsilis ventricosus	May-July.		May, July.	Post. part, outer pair	Oct., Nov.
Lampsilis alatus	July	July		Post. part, outer pair	Nov., May
Lampsilis laevissimus	July-Aug.				
Lampsilis gracilis	May-July.	May, July.	May, July.	Post. part, outer pair	Oct.

THE INFLUENCE OF CHLORINE AS CHLORIDES IN THE DETERMINATION OF OXYGEN CONSUMED IN THE ANALYSIS OF WATER.

J. B. WEEMS. J. C. BROWN.

One of the most valuable determinations in the analysis of water and sewage is the determination of the oxygen consumed. In the deep well waters of the state, the amount of chlorine in the form of chlorides in many cases is very high, as may be seen by the investigations of the Geological Survey,* on the artesian waters.

In this investigation it was found that chlorides were present in the following amounts, as shown in the analysis of water from the places named:

McGregor	967.	parts per million.
Manchester	80.	" " "
Boone	152.	" " "
Davenport	273.	" " "
Centerville	388.	" " "

The selections made contain large amounts of chlorine as chlorides, and while there are many other waters which contain only small quantities of chlorides, it is readily seen that the deep well waters vary between wide limits in the amounts of this substance present in them. It may be said in a general sense, that the amount of chlorine found in the analysis of the deep well waters of the state varies from a small quantity to 1000 parts of chlorine as chlorides per million.

It has been recognized for some years that the presence of chlorine in combinations in the form of chlorides has a certain effect upon potassium permanganate when boiled in the presence of sulphuric acid; and the problem which naturally presents itself is, to what extent is the

* Iowa Geological Survey, Vol. 6.

permanganate solution effected by the presence of a certain amount of sodium chloride in the water with which it is desired to make the determination of oxygen consumed.

The next considertion given was that of selecting the methods which are in general use for the determination of the oxygen consumed. As a result of an investigation of the literature on the subject it may be said that the four following methods are those which are most generally used:

I. KUBEL METHOD.* 100 c.c. of the solution is taken and placed in a flask; 5 c.c. of sulphuric acid (dilute 1.3) is added with a quantity of standard potassium permanganate solution. The contents of the flask are boiled for five minutes; then 10 c.c. of standard oxalic acid solution is added and the solution titrated to color with standard permanganate.

II. SCHULZE METHOD. 100 c.c. of the sample is taken and placed in a flask to which there is added 1-2 c.c. of sodium hydrate (one part of sodium hydrate to two parts of water) and a quantity of standard potassium permanganate which will insure a permanent color to the solution. The contents of the flask are boiled for ten minutes, allowed to cool to a temperature of 50-60°, and 5 c.c. of dilute sulphuric acid is added; 10 c.c. of standard oxalic acid is then placed in the flask and the contents titrated with standard potassium permanganate.

The permanganate solution used in both the Kubel and Schulze methods is a 1-100 normal.

III. THE ASSOCIATION METHOD† as recommended by the chemical section of the American Association for the advancement of science.

To 200 c.c. of the water to be examined in a 400 c.c. flask, add 10 c.c. of dilute sulphuric acid (1.3) and such measured quantity of the permanganate as will give a persistent color; boil ten minutes; add, if necessary, more permanganate in measured quantities so as to maintain the red

* Konig, Landwirstschäfttiche und gewerblichewichtiger Stoffer. 2nd auf. p. 607.
† Leffmann & Beam, Examination of Water, p. 41.

color; remove the flask from the lamp, add 10 c.c. of oxalic acid solution to destroy the color, or more if required by the excess of permanganate, and then add permanganate, drop by drop, till a faint pink tint appears. From the total quantity of permanganate used deduct the equivalent of the oxalic acid used, and from the remainder calculate the milligrams of oxygen consumed by the oxidizable organic matter in the water.

IV. THE ENGLISH METHOD.* This method is the one generally used in England by the Society of Public Analysts.

"Two determinations are made, the amount of oxygen absorbed during fifteen minutes and that absorbed during four hours; both are to be made at a temperature of 80°F. It is most convenient to make these determinations in 12oz. stoppered bottles, which have been rinsed with sulphuric acid then with water. Put 250 c.c. or 3,500 grains in each bottle, which must be stoppered and immersed in a water bath or air bath until the temperature rises to 80°F. Now add to each bottle 10 c c. or 100 grains of the dilute sulphuric acid, and then 10 c.c. or 100 grains of the standard potassium permanganate solution. Fifteen minutes after the addition of the permanganate, one of the bottles must be removed from the bath and two or three drops of the solution of potassium iodide added to remove the pink color. After thorough admixture, run from a burette the standard solution of sodium hyposulphite until the blue color is just discharged. If the titration has been properly conducted, the addition of one drop of the solution of potassium permanganate will restore the blue color. At the end of four hours remove the other bottle, add potassium iodide, and titrate with sodium hyposulphite as just described. Should the pink color of the water in the bottle diminish rapidly during the four hours, further measured quantities of the standard solution of potassium permanganate must be added from time to time so as to keep it markedly pink."

It will be noticed that the method of the Association is very similar to the Kubel method and only differs from it in using double the quantity of water and reagents in the determination, and boiling for ten minutes.

It would naturally be expected that the results from an investigation of these methods, that the action of the chlorine as chlorides would be very little if any in the Schulze and English methods, for in the first there is an alkaline condition present and in the second the temperature is so low that it is only slightly above ordinary temperature.

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* Analyst. 1881, p. 136; also Leffmann & Beam, Examination of Water, p. 39.

In the Kubel and Association methods, however, a reaction would be expected and the permanganate acted upon to a certain extent. As the results from the investigation of these two methods were the same the following table will give the amount of permanganate decomposed for both methods in terms of oxygen consumed.

Parts per million of chlorine as sodium chloride in sample.	Oxygen consumed in parts per million.
5	.03
10	.08
15	.10
20	.13
25	.15
50	.18
100	.23
200	.28
300	.33
400	.38
500	.48
600	.63
700	.72
800	.80
900	.83
1000	.98
1100	1.08
1200	1.24
1400	1.44
1600	1.56
1800	1.68

From these results it is seen that in waters that contain large quantities of chlorides, it is well to give consideration to the action due to the presence of chlorides on the permanganate solution where the Kubel or the Association method is used, for the determination of oxygen consumed.

A STUDY OF SOME COTTON SEED OILS.

J. B. WEEMS. H. N. GRETTENBERG.

In connection with an investigation which was recently made at the Experiment Station it became necessary to investigate a number of cotton seed oils, which were prepared for general use. When it is realized that cotton seed oil, which is one of the cheaper oils, is used in many cases for adulterating oils of a better class it is seen that any data regarding this substance is of value to those who are engaged in the analytical branch of chemistry.

The samples which were investigated were of different grades, as may be seen by the following outline:

SAMPLE No. I—"*Butter Oil.*" Probably could be used as an addition to lard to lower the melting point of this substance and used in the manufacture of oleomargarine.

SAMPLE No. II—"*Cooking Oil.*" Intended for use when oil is desired for cooking purposes.

SAMPLE No. III—"*Snow Flake.*" A good grade of cotton seed oil intended for general use.

SAMPLE No. IV—*Salad Oil.* Prepared for use as a salad oil and could be readily used for adulteration of olive oil.

SAMPLE No. V—*Common Oil*, known as "Summer White."

SAMPLE No. VI—Labeled "Summer Yellow."

SAMPLE No. VII—Labeled "Winter Yellow."

SAMPLE No. VIII—"*Crude Oil.*"

SAMPLE No. IX—Purchased in New York market as common "Cotton Seed Oil."

Allen* gives the standards for cotton seed oil as follows:

Specific Gravity 98°-100°C........	.867—.873
Saponification Equivalent........	190.8—209.7mg
Iodin Number...........	102—111

*Commercial Organic Analysis, Vol. 2, pt. 1, p. 93.

Benedict* and Lewkowitsche give the following constants for cotton seed oil:

Specific Gravity 99°	.8725
Saponification Equivalent........	191—196.5
Iodin Number	100 9—116.9

The specific gravity is that found by Allen while the saponification equivalent is also the result of the investigations of that author. The Iodin number is that found by Wiley.

COTTON SEED OILS.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
Specific Gravity	.90035	.9005	.9003	.9005	.9005	.9005	.9003	.9006	.9005
Volatile Acids	.315	.22	.217	.502	.872	.78	.609	.557	.54
Saponification (equivalent in mg. KOH for 1 gram.)	195.6	198.6	194.4	194.2	195.1	194.9	192.1	192.1	194.8
Soluble Acids	.52	.88	.53	.51	1.85	2.05	1.47	1.85	.85
Insoluble Acids	95.48	94.81	95.61	95.48	94.08	94.58	94.73	93.97	94.66
Iodine Absorption	84.83	88.12	82.08	86.50	96.5	97.4	106.2	106.7	101.8

It will be noticed that the specific gravity of the samples investigated varies from .9003 to .9006 and with an average of .90045. This is considerably higher than that given by either Allen or Benedict and Lewkowitsche.

The limits of the value of the Saponification equivalent as given by Allen are very wide while the other authors give a more restricted limit for the constants of these oils.

The results from the samples vary from 192.1 to 198.6 and with an average of 194.6, the better oils having the higher and the common oils the lower values..

In the Iodin number there is a great variation which depends largely on the nature of the oil, whether of the better grade or not.

The common and crude oils gave results which came within the limits for the constants as stated by Allen and also Benedict and Lewkowitsche.

The better grades of oils, however, give results for the Iodin absorption which are much lower than the limits given for the constants by the authors as quoted.

The methods used in the investigation are those of the Association of Official Agricultural Chemists and published in bulletin No. 46 of the Division of Chemistry (revised edition). The results given are the average of three determinations for each sample.

*Oil Fats and Waxes, p 306.

A STUDY OF A CONTAMINATED WATER SUPPLY.

J. B. WEEMS. J. C. BROWN.

A pure water supply is one of the most valuable possessions which nature can give to any community. The value of a pure water supply is realized more readily by those who live in a city or town where the population is concentrated than by those living in the country where the families are isolated.

A contaminated water supply is a very expensive possession for a city, and as the natural result of experience, great attention is given to insure a pure water supply by the larger cities and towns. Expensive water works and filter beds are erected in order that pure water may be supplied, and the money spent for this purpose is one of the best investments that can be made by a city or town.

In the country and small towns, shallow wells are used as a means of obtaining a water supply. The water which is furnished by these shallow wells is, no doubt, at first in a pure condition, but in course of time little or no attention is paid to the surroundings, and a natural result is that a condition is reached which is favorable for the contamination of the well.

The average individual depends entirely on the taste and smell of a water to determine whether it is pure or not. As long as the water remains clear and has no offensive taste or odor, the water will be regarded as pure. And in this lack of realization, as it were, by those who use shallow wells, there is no doubt the cause of many an epidemic of diseases, the germs of which are readily distributed by means of water. A recent epidemic of typhoid fever gave an opportunity for a chemical investigation of a number of shallow wells, the object of the investigation

being to determine, if possible, the source of the epidemic. It was recognized after an investigation of the hygienic conditions that the water or milk supply must have been the means of transmitting the germ which caused the epidemic. A thorough investigation of the water supply proved that there was no indication whatever of any contamination; and, naturally, attention was given to the milk supply as the probable cause of the disease.

A chemical examination was made of every well which supplied water to those who furnished the milk supply. All of the samples collected were analyzed at once on reaching the laboratory. The results of the analysis showed that all of the wells furnished good water except one shallow well, which gave the following results:

Free Ammonia	.054	parts	per	million.
Albuminoid Ammonia	.174	"	"	"
Solids on Evaporation	904.	"	"	"
Solids at 180°	752.	"	"	"
Solids on Ignition	440.	"	"	"
Nitrogen as Nitrites	.2	"	"	"
Nitrogen as Nitrates	24.	"	"	"
Oxygen consumed in 15 minutes	.16	"	"	"
Oxygen consumed in 4 hours	.96	"	"	"
Chlorine as Chlorides	24.	"	"	"

When the results of this analysis are examined it will be noticed that the amount of nitrogen as nitrates is 24 times that of the standard of the State Board of health. The large amount of chlorine and solids in addition to the large amount of nitrogen as nitrates shows most conclusively that the well was contaminated.

A second analysis of water from the same well a short time after the first analysis gave the following results:

Free Ammonia	.104	parts	per	million
Albuminoid Ammonia	.086	"	"	"
Solids on Evaporation	874.	"	"	"
Solids at 180°	714.	"	"	"
Solids on Ignition	506.	"	"	"
Nitrogen as Nitrates	40.	"	"	"
Nitrogen as Nitrites	.16	"	"	"
Oxygen consumed in 15 minutes.	.64	"	"	"
Oxgen consumed in 4 hours	.06	"	"	"
Chlorine as Chlorides	26.	"	"	"

In comparing the results of the second analysis with the first analysis, it will be noticed that the amount of nitrogen as nitrates, has increased from 24 parts to 40 parts per million, while the albuminoid ammonia has decreased.

These results indicate that the nitrogen in the organic matter which was present in the water has been changed during the process of nitrification into nitric acid. This change has probably taken place during the passage of the water through soil in which the conditions were favorable for the nitrifying process.

When inquiries were made regarding the use of this well, the claim was made by the owner that it was not used, but that a deeper well, which was near the shallow well, furnished the water. It was discovered, however, on visiting the place one morning, that a bucket of water was being pumped from this well for drinking purposes, and was supplied to a number of men working on the railroad near the place. The deep well proved to have a very limited supply of water when tested; and it was then claimed that the shallow well water was used only for washing out the milk cans, etc. A case of typhoid fever had occurred in the family of the farmer during the summer, and on tracing the case it was found, that this case and the epidemic were closely related when consideration was given to the time necessary for the development of the disease The number of cases were from forty-five to fifty, and almost the entire number of patients came from those who used the milk furnished by the farm with the contaminated well. It was also found on investigation by the physician that a number of the laborers on the railroad had developed cases of typhoid fever. The conclusion naturally reached is, that the well was contaminated from some source, and at the time at which the case of typhoid fever was in progress in the family of the farmer, contained the typhoid germ. The use of this water for washing milk cans without boiling, transmitted the germ to the milk, and by the milk to the digestive system of the persons using the milk.

The well which proved to be the source of the epidemic was the only one which was contaminated among the wells examined, yet we cannot but realize that there are distributed in the small towns and on the farms many such wells, which are in the condition of a gun which is not supposed to be loaded, but is liable to "go off" at any time with disastrous results.

There is no doubt that little or no attention is given to the water and milk supplies as long as Providence in some mysterious manner protects those who tempt her in many ways, but when the penalty is paid, it is a costly one, for instruction furnished by "experience" is in many cases very expensive.

DIPHENYL ETHER DERIVATIVES.

ALFRED N. COOK.

(1) HISTORICAL INTRODUCTION.

(2) PREPARATION OF A NITRO-METHYL DERIVATIVE.

(3) OXIDATION OF THE METHYL GROUP TO AN ACID AND THE PREPARATION OF SOME OF THE SALTS OF THE ACID.

(4) REDUCTION OF THE NITRO GROUP TO FORM A BASE AND THE FORMATION OF THE PLATINUM SALT.

(5) BIBLIOGRAPHY.

HISTORICAL:—In the year 1854, Dr. K. List and Dr. H. Limpricht (Ann. 90, 190) were studying the products of the destructive distillation of copper benzoate and succeeded in identifying the principal product as phenyl benzoate. During the process of purification they separated from this by fractional distillation a substance to which they assigned the formula, $C_{23}H_9O_2$, and called it phenyl oxide. (Dr. John Steinhause had previously studied the products of the distillation of copper benzoate (Ann. 53, 91), but did not detect the substance in question). Limpricht

(Lehrbuch, p. 713), afterwards made a further study of the compound and assigned it to the formula $C_{12}H_{10}O$. Rudolph Fittig (Ann. 125, 328), in 1863, prepared from the above mentioned distillate by means of sulphuric acid a compound which he called diphenyl and assigned the formula, $C_6H_5.C_6H_5$ and made the supposition that the reaction took place according to the following equation:

$$\left.\begin{matrix} C_6H_5 \\ \\ C_6H_5 \end{matrix}\right\} O + 2H_2SO_4 = C_{12}H_8.\ \ H_2S_2O_8 + (C_6H_5)_2 + 2\ H_2O.$$

Kekule (Lehrbuch. Vol. III, 19), opposed the formula of List and Limpricht on the ground of Fittig's work, and argued that it must be monohydroxy diphenyl ($HO,C_6H_5.C_6H_5$), which would have the same empyrical formula.

C. Lesimple in 1867 (Ann. 138, 375), prepared a substance by distilling tryphenyl phosphate with an excess of lime, which he called phenyl oxide, although his analysis shows that the per cent of hydrogen was .9 too low. The melting point also was 53° too high, but this he could not have known, as List and Limpricht's compound remained a liquid. (This was afterwards shown by Hoffmeister to be due to impurities.)

In view of all the uncertainty that existed, W. Hoffmeister in 1871 (Ann. 151, 191), set out to determine whether diphenyl ether had really been prepared or not. He repeated the experiments of List and Limpricht, but distilled off the compound in question from the phenyl benzoate with steam instead of separating by fractional distillation, and thus obtained the substance in a much purer state. It was then a crystalline solid, and had a melting point of 27° C. He showed that diphenyl could not be obtained from this crystalline compound by the action of sulphuric acid, but that it occurred as an impurity when diphenyl ether was made by the method of List and Limpricht, and Fittig had simply separated it. Kekule was therefore wrong with regard to the constitution of the compound. He also

showed that Lesimple (Ann. 159, 192), had made diphenilene oxide instead of diphenyl oxide.

Up to the present time diphenyl ether and its derivatives have been prepared by at least thirteen different methods, and have been studied by no less than twenty-five different chemists, among whom were Fittig and Kekule. While the methods are various, the yield in almost every case is remarkably small. The leading methods that have been used are as follows:

W. Hoffmeister (Ber. 3, 747) prepared diphenyl ether by warming diazo benzine sulphate and phenol, but the yield was very small. Hirsch (Ber. 23, 370) used the chloride instead of the sulphate and modified the method in some other respects and obtained a yield of 50 per cent of the aniline used.

Merz and Weith (Ber. 14, 187) obtained a small yield by heating phenol with zinc chloride, and also with aluminum trichloride.

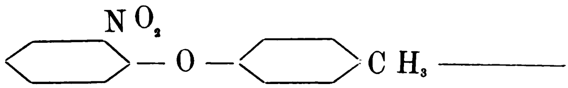
Gladstone and Tribe (Jr. Chem. Soc., 41, 5 and ditto 49, 27) made various methyl phenyl ethers by distilling the corresponding aluminum cresolates.

Willgerodt (Ber. 12, 1278) obtained a large yield of the trinitro derivatives by heating pikryl chloride with one molecular equivalent of potassium hydroxide.

One of the most productive methods that has been used is that originated by Haeussermann and Teichmann (Ber. 29, 1446), and also independently by F. Ullmann (Ber. 29, 1878). The heated potassium phenolate and several of its derivatives with the various nitro halogen derivatives of benzine and obtained, as a rule, a good yield.

EXPERIMENTAL PART:—In approaching the study of diphenyl ether derivatives, it was suggested by Dr. H. W. Hillyer of the University of Wisconsin, that the method of Haeussermann and Teichmann might be extended to the Cresols, and in the following account it will be seen that this was accomplished with a good degree of success. It has seemed best to adopt the nomenclature of Haeussermann and Bauer (Ber. 29, 2083) as the simplest, and at the same time susceptible of very extended application.

2-nitro-4′-methyl phenyl ether——



This compound was prepared by the action of o-brom nitro benzene on potassium p-cresolate and the reaction takes place according to the following equation:

$$NO_2.C_6H_4Br+KO.C_6H_4.CH_3 = NO_2.C_6H_4OC_6H_4.CH_3+KBr.$$

The potassium p-cresolate was made by treating one part of p-cresol with a molecular equivalent of potassium hydroxide dissolved in one part of water, evaporating to dryness on the water bath, with continual stirring and then drying in the air bath at 100° C. for half an hour. This method yielded a very good product, which was of a slight yellow color. An endeavor to prepare the cresolate by dissolving metallic potassium in the cresol, as did Haeussermann and Teichmann (Ber. 29, 1446), and F. Ullmann (Ber. 29, 1878), with phenol in making derivatives of diphenyl ether, yielded a dark tarry product which very materially effected the yield and purity of the diphenyl ether which was made from it. The above mentioned ether was made in the following manner: One part by weight of potassium p-cresolate was heated in a small Florence flask on a fusible metal bath with three parts of o-brom-nitro benzene to 125–130° C. when a vigorous action began, accompanied by a rise of temperature of several degrees. As soon as the action had ceased, which required about five minutes, the melt was cooled and extracted with ether. The above mentioned ether extract was washed with potassium hydroxide solution to remove any free cresol which might be present. The excess of o-brom-nitro benzene was distilled off with steam, and the phenyl ether was distilled under diminished pressure to free it from any remaining trace of ortho-brom nitro benzene, and the solid, and higher boiling substances which were extracted with the sulphuric ether. Under a pressure of 25 mm. o-brom nitro benzene boils at 150° C., while 2-nitro-4′-methyl phenyl ether boils at about 220° C.

under the same pressure. The yield was one gram of the ether for every gram of the cresol used. On crystallizing several times from alcohol it was completely purified and analysis yielded the following results:

	Carbon.	Hydrogen.	Nitrogen.
Calculated for $C_{13}H_{11}NO_3$	.. 68.04	4.83	6.11 per cent.
I	....68.12	4.75	6.28 per cent.
II	....68.20	4.77	6.32 per cent.

The compound melts at 49° C. It distills with partial decomposition at ordinary atmospheric pressure. It is not volatile with steam. It is very soluble in hot alcohol, from which it crystallizes out in beautiful sulphur yellow, and apparently monoclinic crystals of sufficient size to be easily measured with the goniometer. It has no taste, but feels like sulphur when taken into the mouth. It is very soluble in ether, acetic acid, chloroform, benzene, toluene, aniline, nitro benzene, ethyl acetate, acetone, benzoyl chloride, brom benzene and carbon disulphide. It is sparingly soluble in petroleum ether, and insoluble in water and hydrochloric acid. It is dissolved by concentrated sulphuric acid with slight charring and by concentrated nitric acid with apparent oxidation, brown fumes being given off.

2-Nitro phenyl ether-4'-carbonic acid——$NO_2.C_6H_4OC_6H_4.COOH$——This acid was prepared by dissolving the above mentioned ether in glacial acetic acid (which had been prepared by distilling Kahlbaum's glacial acetic acid from chromic acid) warming on the steaming water bath and adding very slowly a cold solution of chromium trioxide in glacial acetic acid until a test portion failed to become turbid upon diluting with a large amount of a weak solution of sodium hydroxide. To accomplish this, three or four times the theoretical quantity of chromium trioxide was necessary. To a portion of the ether many times the theoretical quantity of chromium trioxide sufficient for oxidation was added and no trace of the acid could be found in the solution. The acid itself had thus probably become completely oxidized. When the oxidation of the ether was judged to be complete, the acid was precipitated from the acetic acid solution by diluting with a large amount of

water. It was purified by washing with water, dissolving in weak ammonia and filtering to remove any traces of the original mother substance, reprecipitating with hydrochloric acid and recrystallizing from dilute alcohol two or three times. The yield in the first experiment was 24 per cent of theory. Later experiments apparently yielded better results, but the resulting quantity of acid was not weighed. The pure acid melts at 182-3° C. It is of a light yellow color and has no taste. It is slightly soluble in hot water, from which on cooling it crystallizes out in tufts of radial needles. It is insoluble in petroleum ether, sparingly soluble in sulphuric ether, but is very soluble in warm alcohol and in dimethyl aniline, benzaldehyde, nitro benzene, toluene, glacial acetic acid and glycerine. The acid was analyzed by determining the amount of silver in the silver salt which yielded results as given below. In the second analysis the silver salt had darkened somewhat by being allowed to remain some time in contact with a solution of silver nitrate during the process of manufacture:

	Calculated for $AgC_{13}H_8NO_5$	I.	II.
Ag.	30.09	30.09	30.59

A portion of the acid was dissolved in dilute ammonium hydroxide, the excess of ammonia evaporated off and observations made as to the character of the precipitates yielded by various metallic salts, with results as follows:

Copper sulphate	light greenish blue.
Aluminum chloride	white.
Lead nitrate	white floculent.
Manganese chloride	white.
Cobalt chloride	light pink.
Magnesium sulphate	white.
Ferric chloride	yellowish white.
Ferrous sulphate	light yellow.
Cadmium chloride	white crystalline.
Mercuric chloride	white.
Platinum tetrachloride	yellow.

Nickel, calcium, strontium and barium salts yielded no precipitate with the dilute solutions used. The solution was very dilute, and in some cases would undoubtedly have yielded a precipitate if it had been more concen-

trated as e. g., the barium salt. When the acid is dissolved in a solution of sodium, potassium or ammonium hydroxide a deep yellow colored solution is obtained.

Silver-2-nitro-4'-phenyl ether carbonate——$AgOOC.C_6H_4OC_6H_4.NO_2$——The silver salt was prepared by dissolving a portion of the acid in dilute ammonium hydroxide, evaporating off the excess of ammonia and precipitating with silver nitrate. It separates out in pinkish curdy lumps. It is sufficiently soluble in water to yield a slight turbidity when hydrochloric acid is added to the solution. When pure and dry it is very stable and is not decomposed by direct sunlight, even when exposed for several hours. It is insoluble in inorganic solvents in general, and melts with decomposition at about 220° C. One part of the salt is soluble in 2180 parts of water at ordinary room temperature.

Barium-2-nitro-4'-phenyl ether carbonate——$Ba[OO.C_6H_4OC_6H_4.NO_2]+1\frac{1}{2}H_2O$.——The barium salt was prepared by adding a little more than the theoretical quantity of barium hydroxide to a strong water solution of the ammonium salt obtained as given above in the manufacture of the silver salt. The excess of barium was precipitated from the solution by passing in a stream of carbon dioxide. The salt crystallizes out from a hot water solution on cooling in pearly flesh-pink scales. One part of the salt dissolves in 122 parts of boiling water and in 948 parts of cold water. Before making an analysis it was dried over sulphuric acid for several days and then dried in the air bath for three or four hours at 100-110° C. Between 80 and 100 degrees it took on a much deeper hue, which seemed to be permanent and lost water corresponding to $1\frac{1}{2}$ molecules. Two analyses resulted as follows:

	Calculated for $Ba(C_{13}H_8NO_5)_2+1\frac{1}{2}H_2O$.	I	II
Barium	19.37 per cent	19.32 per cent.	19.03 per cent.
Loss of water	7 64	7.35	7.06

2-amido-4'-methyl phenyl three——$H_2N.C_6H_4OC_6H_4.CH_3$——The amido ether was prepared by dissolving the previously described phenyl ether in alcohol and water and reducing with tin and hydrochloric acid while warming on the

water bath to 40 or 50 degrees. During the reduction the solution was sky blue, but when complete it usually changed to a pinkish color. The end of the reaction was determined by taking a test portion and diluting with several times its own volume of water. If any unreduced ether was present it would be precipitated, forming a white turbidity. The tin was removed from the solution by means of hydrogen sulphide and, on concentration on the water bath, the hydrochloride crystallized out in white needles, which were very stable when dry, but unstable in contact with water. The hydrochloride melts at 220° C. It is somewhat soluble in hot, but much less soluble in cold water, and insoluble in organic solvents in general. The constitution of the compound was ascertained by determining the platinum in the platinum salt, as given below.

An attempt to prepare the free base by precipitating it with an alkaline hydroxide from a water solution of the hydrochloride proved unsuccessful. It decomposed in the bell jar over sulphuric acid before it could be thoroughly dried.

4-Methyl-2′-amido phenyl ether chlor-platinate—— $(CH_3.C_6H_4OC_6H_4.NH_2)_2.H_2PtCl_6+1\frac{1}{2}H_2O$——The platinum salt was prepared by precipitating the amido hydrochloride in water solution with chlor platinic acid. It is of a greenish yellow color and melts with decomposition at 150° C. The salt was dried for several days over sulphuric acid and then in the air bath at 100-110° C for three or four hours when it lost weight corresponding to one and one-half molecules of water. On being heated it assumes a much deeper tint, but on coming in contact with the air again it acquires its original color. It is very hygroscopic and gains weight very rapidly while being weighed. An analysis resulted as follows:

	Calculated for $(C_{13}H_{13}NO)_2.H_2PtCl_6+1\frac{1}{2}H_2O$	Found.
Platinum....	24.1 per cent	24.1 per cent.
Loss of water	3.23	3.03

A further study of diphenyl ether derivatives is being carried on in the chemical laboratory of Morningside Col-

lege, and as this paper is to be made the basis for future work a bibliography of diphenyl ethers is here appended.

BIBLIOGRAPHY.

(1) Ann. 90, 209.—List and Limpricht obtained diphenyl ether as one of the products of the destructive distillation of copper benzoate.

(2) Ann. 125, 325.—Rudolph Fittig obtained diphenyl from the above mentioned distillate.

(3) Ann. 138, 375.—C. Lesimple obtained a compound by distilling phenyl phosphate with lime, which he called phenyl ether.

(4) Ann. 159, 191, and Ber. 3, 747.—W. Hoffmeister prepared phenyl ether by treating diazo-benzene sulphate with phenole and made a thorough study of the compound.

(5) Ber. 23, 3709.—Hirsch varied Hoffmeister's method and greatly increased the yield.

(6) Ber. 6, 564.—Maikopar made a dinitro derivative by acting on dinitro chlor benzene with an alcoholic solution of potassium hydroxide and phenol.

(7) Ber. 13, 887.—Willgerodt prepared a tetra nitro-derivative by heating dinitro-potassium phenolate with dinitro-chlor benzene in a sealed tube.

(8) Ber. 14, 187.—Merz and Weith prepared pheny ether by heating phenol with zinc chloride, and also aluminum chloride (see also correspondence, Ber. 12, 1925.)

(9) Ber. 15, 1123.—Niederhausern prepared methylene diphenyl-oxide by distilling sodium phenolate with sodium meta-phosphate.

(10.) Ber. 17, 1764.—Willgerodt and Huetlin prepared derivatives by acting on potassium phenolates with dinitro-chlor benzene and pikryl chloride.

(11) Ber. 17, 2638.—Bausch prepared a dimethyl derivative by heating para-cresol with zinc chloride.

(12) Ber. 29, 1446.—Haeussermann and Teichman prepared various derivatives by acting on halogen-nitro benzene derivatives with potassium or sodium phenolates.

(13) Ber. 29, 1878.—F. Ullman, independently from the above mentioned investigators, made a few compounds by the same method.

(14) Ber. 29, 2083, and *Ibid*, 30, 738.—Haeussermann and Bauer continued the work begun by Haeussermann and Teichman and prepared numerous compounds.

(15) Jr. Chem. Soc. (Lond.), 41, 5, and *Ibid*, 49, 27.—Gladstone and Tribe prepared phenyl ether and derivatives by distilling aluminum phenolate, aluminum thymolate, and aluminum cresolates.

(16) Chem. News, 42, 3.—See No. 15 above.

(17) Chem. News, 42, 146.—See No. 8 above.

(18) Jr. Pr. Chem. 1, 143.—See No. 4 above.

(19) Jr. Pr. Chem. (2) 28, 273.—Klepl prepared carbonyl phenyl oxide by the action of triphenyl phosphate on sodium salicylate.

(20) Jr. Pr. Chem. (2) 28, 193.—Klepl prepared phenyl ether by distilling para-phenoxy benzoic acid with caustic baryta.

(21) Jr. Pr. Chem. (2) 28, 201.—Richter prepared diphenyl oxide by distilling sodium salicylate and triphenal phosphate.

(22) Monats Hefte, 17, 65.—B. Jeitles distilled calcium phenyl phosphate and obtained, among other things, diphenyl ether.

(23) Gazetta, 28 (1), 197.—G. Ortoleva and A. Paratoner treated diphenyl ether with sulphonyl chloride and obtained chlorine derivatives. (Abstract in Journal of the London Chemical Society, 1898.)

SOME RECENT ANALYSES OF IOWA BUILDING STONES; ALSO OF POTABLE WATERS.

NICHOLAS KNIGHT.

A. Building Stones—

The rocks herein described were analyzed in the chemical laboratory of Cornell College, under the direction of Dr. N. Knight. The composition of the rocks varies from nearly typical dolomite to admixtures in different proportions of calcium carbonate and dolomite.

1. This is a bluish drab saccharoidal rock, situated near the base of the Iowa Devonian series, at Rochester, Iowa. It is of special interest because locally believed to contain silver. A miner's shaft twenty-two feet deep has been sunk to it, and several analyses are said to have been made, showing a large amount of silver. Professor W. H. Norton, of the Iowa Geological Survey, was unable to authenticate any of the analyses. He found no geological grounds for the slightest suspicion of any precious metal in these beds. This analysis was made, not to disprove the presence of silver, but to show the lithological change from the subjacent dolomites of the Silurian. The specimen was analyzed by Miss Minerva Herrinton, A. B.

$CaCO_3$	78.75 per cent.
$MgCO_3$	20.16 per cent.
Fe_2O_3 and Al_2O_3	0.10
SiO_2	0.4 per cent.
MnO_2	0.2 per cent.
Total	99.61 per cent.

The rock varies widely from a true dolomite, which contains

$CaCO_3$	54.35
$MgCO_3$	45.65

2. The Coggon beds, as described by Professor W. H. Norton in the reports of the Iowa Geologial Survey, overlie the Gower stage of the Silurian, and are immediately beneath the Otis beds of the Wapsipinnicon stage, the lowest Devonian terrane recognized in Iowa. The lithological affinities of the Coggon are with the Niagara, but the very meagre fauna inclines rather toward the Onondaga limestone of the Devonian. The specimen from Bieler's quarry in Cedar county, was analyzed by Miss Herrinton.

$CaCO_3$	58.2	per cent.
$MgCO_3$	39.5	
Fe_2O_3 and Al_2O_3	0.9	
SiO_2	1.2	
Total	99.8	per cent.

This is not a true dolomite, but more nearly approaches it than the rock described in 1.

3. The Gower stage as defined by Professor Norton includes two distinct lithological types: A hard crystalline rock used extensively for lime, and hitherto known as the LeClaire limestone; and a granular, evenly-bedded rock which furnishes the best building stone in the state. This was until recently designated as the Anamosa beds, which have usually been assigned rank as a distinct geological formation; but the Iowa Geological Survey in its recent reports, has taken them to be but a lithogical phase of one formation. The name *Gower* has been assigned them from the township in Cedar county in which the important Bieler quarries are situated. Both types of rock are found in the Bieler quarries. The specimen of the granular laminated building stone was analyzed by Miss Herrinton. It varies only slightly from a true dolomite.

$CaCO_3$	56.4	per cent.
$MgCO_3$	42.6	
Fe_2O_3 and Al_2O_3	0.7	
SiO_2	0.4	
Total	100.1	per cent.

4. Specimen of the Gower phase taken from the quarry at Mount Vernon. Analyzed by Mr. E. A. Rayner.

$CaCO_3$	54.02 per cent.
$MgCO_3$	44.73
Fe_2O_3 and Al_2O_3	0.61
SiO_2	0.29
Total	99.65

The rock is nearly a typical dolomite.

5. The rock at the Palisades on the Cedar river, six miles distant from Mount Vernon, is similar in composition to the Mount Vernon Rock. It is stratified, but not granular. Building stone occupies layers adjacent to others which are burned for lime. The specimen was analyzed by G. R. Greaves.

$CaCO_3$	53.64 per cent.
$MgCO_3$	43.89 per cent.
Fe_2O_3 and Al_2O_3	0.52
SiO_2	1.98
Total	100.03 per cent.

6. This is of the same type as 3. It is a finely laminated building stone, but crystalline instead of granular. The specimen analyzed by Miss Herrinton is from the large quarries at Lime City. It is nearly a dolomite in compostion.

$CaCO_3$	55.3 per cent.
$MgCo_3$	43.0
Fe_2O_3 and Al_2O_3	1.4
SiO_2	0.6
Total	100.3 per cent.

7. This is also a representative of the Gower limestone and of the LeClaire lithological phase. The specimen was taken from a ledge on Rock creek, two and a half miles southwest of Tipton. The ledge is notable for its exceptionally high dip, reaching 70°. It varies but little from a true dolomite. The analysis was made by G. R. Greaves.

$CaCO_3$	55.76 per cent.
$MgCO_3$	43.85

Fe_2O_3 and Al_2O_3	0.26
SiO_2	0.12
Total	99.99 per cent.

Each of the seven specimens examined is nearly pure calcium and magnesium carbonates. The admixtures of iron, alumina, and silica are quite insignificant.

B. POTABLE WATERS OF MOUNT VERNON—

1. *Prof.* W. *H. Norton's Well.* The well is eighty feet deep and draws its water supply from sand situated between an upper yellow and a lower blue till. The numbers in this and in the succeeding analyses express the parts of the substances in a million parts of water in conformity with the report of the committee of the American Association for the Advancement of Science.* The water was analyzed in May, 1900, by F. E. Welstead.

Total solids at 110°	364.8
$CaCO_3$	218.2
$MgCO_3$	105.8
SiO_2	21.6
Fe_2O_3 and Al_2O_3	2.6
NaCl and KCl	19.8
Na_2CO_3 and K_2CO_3	2.8
CO_2 free and partly united	15.9
Nitrates	0.05
Free ammonia	0.00
Albuminoid ammonia	0.00

2. *Professor A. Collin's Well.* Analyzed May, 1900, by E. A. Rayner. The depth of the well is one hundred and twenty feet. A dense blue till begins at a depth of eighty-five feet, and extends as far down as the excavation was made. In the upper yellow till, a layer of sand and gravel was found at a depth of seventy to seventy-five feet.

Total solids at 110°	359.8
$CaCO_3$	195.00
$MgCO_3$	102.4
SiO_2	21.2
Fe_2O_3 and Al_2O_3	1.6

*Journal of Analytical Chemistry. Vol. III, page 398.

NaCl and KCl	21.4
CO_2 free and partly united	61.5
$CaSO_4$	10.2
Nitrates	0.57
Free ammonia	0.064
Albuminoid ammonia	0.088

3. *John Leigh's Well.* The depth is one hundred and fifty feet of which the last fifty feet are in the Niagara limestone. Analyzed May, 1900, by Miss Herrinton.

Total solids	370.6
$CaCO_3$	215.0
$MgCO_3$	102.9
SiO_2	20.8
Fe_2O_3 and Al_2O_3	7.8
NaCl and KCl	6.6
Na_2CO_3 and K_2CO_3	10.00
CO_2 free and partly united	162.00
Sulphates	0.00
Nitrates	0.57
Free ammonia	0.00
Albuminoid ammonia	0.00

4. *G. W. Young's Well.* This is in the same locality as Mr. Leigh's. The well is one hundred and fifty-three feet deep, of which fifty-three feet are in the Niagara limestone. The analysis was made May, 1900, by F. E. Welstead.

Total solids	348.3
$CaCO_3$	230.0
$MgCO_3$	73.9
SiO_2	20.4
Fe_2O_3 and Al_2O_3	3.00
NaCl	19.00
KCl	trace.
CO_2 free and partly united	159.00
Sulphates	0.00
Nitrates	1.00
Free ammonia	.048
Albuminoid ammonia	.072

5. *The Mount Vernon City Water.* The well is three hundred and thirty feet deep and extends three hundred and fifteen feet into the Niagara limestone. It goes nearly through the Niagara, as shown by thin layers of shale that were found near the base of the boring, transitional to the heavy shales of the Maquoketa stage, beneath

the Ordovician. The water contains twenty to twenty-five per cent less of calcium and magnesium carbonates than the other waters examined. This may result from an artesian character of the well, the water coming from sandstones underneath the Niagara; or a small adjacent stream may find its way into the well through fissures in the rock. Several analyses showing a varying amount of free and albuminoid ammonia may incline rather to the latter alternative. The analysis was made in May, 1900, by Miss Herrinton.

Total solids	286 6
$CaCO_3$	154.9
$MgCO_3$	97 0
SiO_2	23.00
Fe_2O_3 and Al_2O_3	80
NaCl and KCl	24.00
CO_2 free and partly united	114.00
$CaSO_4$	4 08
Nitrates	1 38
Free ammonia	0 084
Albuminoid ammonia	0.032

6. *The Cedar River*. The sample was taken from the river at Ivanhoe bridge, May, 1900; analyzed by Mr. Rayner.

Total solids	234 2
$CaCO_3$	147 1
$MgCO_3$	57.5
SiO_2	2.0
Fe_2O_3 and Al_2O_3	2.2
NaCl and KCl	20.0
CO_2 free and partly united	80.0
$CaSO_4$	5.1
Nitrates	0.77
Free ammonia	0.12
Albuminoid ammonia	0.27

In all the waters examined the ratio of magnesium carbonate to calcium carbonate is about one to two with the exception of Mr. Young's water where the ratio is one to three.

We desire to thank Professor W. H. Norton for valuable suggestions in connection with these investigations.

CONTRIBUTION TO THE STUDY OF REVERSIBLE REACTIONS.

W. N. STULL.

The object of this investigation has been to determine the points of equilibrium in the reactions resulting when solutions of metals are treated with hydrogen sulphide, and to determine the changes of those points with regard to changes of temperature. As the work advanced the importance of the question of the rate of the reactions became more and more apparent, and as a result I have dealt at considerable length with this factor and with the effects of temperature and agitation upon it.

The two metals first employed are zinc and cadmium, chiefly because an investigation of the action of hydrogen sulphide upon these would not only serve the original purpose of the study, but, it was thought, might throw considerable light upon their quantitative separation. The present paper, which is to be considered as merely preliminary, deals with the rate of the reactions in solutions of zinc and cadmium.

Of course when hydrogen sulphide acts upon zinc chloride we have a reversible reaction represented as follows:

$$ZnCl_2 + H_2S \rightleftarrows 2HCl + ZnS,$$

which in the beginning runs rapidly from left to right, but diminishing as zinc sulphide and free hydrochloric acid are formed and react upon each other in the direction from right to left. By "diminishing" is here meant the diminishing effect, and not the rate of interaction between the molecules. This is dependent only upon the concentration of the reacting substances, and a specific rate of the reaction which is independent of the concentration.

If we call the original concentration of zinc C, and start with a neutral solution the equivalents of ZnS precipitated or the HCl set free at any moment X,—and the specific rates of the reactions from left to right and from right to left, respectively, k and k_1, then the rates at any moment will be $(C-K)h.k$ and $K_2.k'$ and equilibrium will be reached when $(C-X)h.k = X_2.k'$, where h represents the hydrogen sulphide which is regarded here as constant.

Before proceeding with the presentation of the data, a few words regarding the quantitative methods used are desirable. It was necessary to determine the total acid in each solution at the beginning, and the metal remaining in the solution at the end of any chosen period. From these data the free acid at the end of any period could be calculated. Sulphuric acid was determined as barium sulphate in the usual way, hydrochloric acid volumetrically by the method of Volhard, cadmium as the sulphide which was weighed in a Gooch crucible, and zinc by the ferrocyanide method of Lyte.

The last named method seems not to have attained a use to which its accuracy and rapidity entitles it, and a few words in recommendation of it are not deemed inappropriate. The solution is acidified with hydrochloric acid and titrated with a solution of potassium ferrocyanide which has been standardized by a zinc solution of known strength, the titrations being carried on at about 70°. Uranium acetate is used as an indicator. A few drops may be added to the solution which is colored brown when the ferrocyanide is added in slight excess. It is more exact to bring a drop of the solution under titration and near the end point, in contact with a drop of the indicator on filter paper. A brown line is formed where the two drops flow together. With care titrations are concordant to a few hundredths of a per cent., and the method seems to deserve rank among the standard methods of volumetric analysis.

The zinc used in this work was a pure distilled specimen from Schuchardt, which dissolved without residue and gave

a sulphide which was perfectly white. The cadmium was from the same manufacturer and gave a pure, bright yellow precipitate in acid solution.

The solutions to be treated with hydrogen sulphide were placed in tubes holding about 100 c.c., immersed in a large water bath kept at constant temperature by means of a thermostat, and a stirrer driven by a small hot air motor. At first a thermometer graduated in tenths was placed in the solution and the temperature kept within 1/0.1° of the desired point, but this was discontinued when it was found how small is the influence of temperature upon the rate of precipitation. At temperatures above that of the laboratory the hydrogen sulphide was first passed through a tube immersed in the bath and containing water, in order to compensate for any loss by evaporation. The hydrogen sulphide was generated in a Kipp's apparatus and washed by passing it through water. The rate of the gas was about two bubbles per second, or about three to four liters per hour. Where not otherwise stated the temperature of precipitation was 20°.

At first the thought was to make the determinations in duplicate and to this end the gas was passed through two solution tubes connected tandem. The following table shows the results. Numbers 1 and 3 are the solutions nearer the Kipp's apparatus and 2 and 4 are their duplicates. The solution used was nearly neutral zinc chloride:

SERIES I.

NO. OF EXAMINATIONS.	TIME—HOURS.	% ZINC IN SOLUTION.	% FREE ACID IN SOLUTION
1	3	1.454	3.24
2	3	1.736	2.92
3	3	1.503	3.18
4	3	1.750	2.86

The fact that the duplicates contain much more zinc than 1 and 3 led at once to the conclusion that precipitation was by no means completed in three hours, even though the gas had actively bubbled through the solutions during the entire time. This came somewhat as a surprise, and naturally all other objects were placed aside until it could be determined whether it was practicable to

reach an equilibrium in this reaction. To this end the following series of determinations was made. As may be seen from the table the precipitation is most rapid about an hour after the beginning, then falls slightly and soon becomes nearly uniform. In general it may be said, that within the total period, the amount of precipitation is nearly proportional to the time, and at the end of seven and a half hours the reaction is yet far from a state of equilibrium. The result is plotted in curve "M," and from it one might easily infer that with sufficient time the precipitation of zinc even in this strength of acid might be complete.

SERIES II.

NO, OF EXAMINATIONS.	TIME—HOURS.	ZN IN SOLUTION.	FREE HCl.
1	½	4.30	
2	1	3.84	0.57
3	1½	3 47	0 98
4	2	3 00	1 53
5	2½	2.78	1.76
6	3	2 63	1 92
7	3½	2.48	2.09
8	4	2.31	2.27
9	4½	2.25	2.35
10	5	2 13	2.48
11	5½	1.98	2 65
12	6	1.92	2 72
13	6½	1 81	2.84
14	7	1 69	2 98
15	7½	1 55	3 18

Experiments were now undertaken to ascertain the influence of time alone. The results are given in the table below, in which X represents the time during which the gas was passed through the solution, and Y gives the time during which the solution was allowed to stand in contact with the precipitated zinc sulphide before it was filtered and the zinc determined. The results evidently point to a three-sided equilibrium between hydrogen sulphide, zinc chloride and hydrochloric acid:

SERIES III.

NO. OF EXAMINATIONS.	X.	M.	ZN IN SOLUTION.	FREE HCl.
1	2	18	1.13	3.62
2	1	18	2.40	2.18
3	1	42	2.40	2.17

Four other experiments were performed consecutively upon the same solution with the results given below. In experiment (3) the solution after standing twelve hours was shaken for one and one-half hours, and a portion filtered off and the zinc determined. It should be mentioned that all the solutions after long standing smelled strongly of hydrogen sulphide.

SERIES IV.

NO. OF EXAMINATIONS.	X.	M.	ZN IN SOLUTION.	FREE HCl.
1	1		1.88	2.82
2	1	12	1.56	3.11
3	1	13½	1 57	3.10
4	3½	13½	0.89	3 87

Series III and IV are not comparable since the precipitation vessels and the volumes of the solutions were not the same.

Even though the agitation seemed to have little effect as shown in Series IV, it seemed desirable to try a series of experiments to determine the effect of agitation while hydrogen sulphide is passing through the solution. To this end two solutions at the same temperature were simultaneously treated with hydrogen sulphide flowing from two generators and at very nearly the same rate. In one of the tubes was a small stirrer. The effect seems to be a slight acceleration of the reaction.

SERIES V.

NO. OF EXAMINATIONS.	TIME.	TOTAL HCl.	ZN REMAINING IN STIRRED SOLUTION.	ZN IN SOLUTIONS NOT STIRRED.
1	1	4.86	3 53	3.65
2	2	4 86	2.85	2 80
3	3	4.86	2.15	2.23
4	4	4 86	1.73	2.01

The effect of temperature was next considered. A new solution of zinc containing 3.94 per cent of hydrochloric acid and 3.49 per cent of zinc was used, with the results given in Series VI.

SERIES VI.

NO. OF EXAMINATIONS.	TEMPERATURE.	TIME.	ZN REMAINING IN SOLUTION.
1	20°	5 hours	1.41
2	50°	5 hours.	1.49

It is evident that a difference of 30° causes very little difference in the rate of precipitation, and probably the point of equilibrium is only very slightly shifted by change in temperature, but the latter point has not yet been determined.

A solution of zinc sulphate was next used, in order to determine the part played by the acid. The method employed was essentially the same as that previously described, namely, fractional precipitation and the determination of the zinc and free acid in the several fractions. The rate of the gas was, as before, about four liters per hour. It will be observed that the precipitation is practically complete at the end of seven hours, even though 4.47 per cent of free sulphuric acid was present. In general the curve closely resembles that of the chloride.

SERIES VII.

NO. OF EXAMINATIONS	TIME	ZN REMAINING IN SOLUTION.	FREE H_2SO_4.
1	1½	1.60	2.18
2	2	1.25	2 65
3	3	.75	3 40
4	4	.38	3.95
5	5	.18	4.26
6	6	.07	4.38
7	7	.03	4.47

In order to find the point of equilibrium, if possible, a solution containing more acid was used. As may be observed in Series VIII, precipitation was still going on at the end of ten and a half hours when there was 5.25 per cent of free acid in the solution. The results are shown graphically in curve Y.

SERIES VIII.

NO. OF EXAMINATIONS.	TIME.	ZN REMAINING IN SOLUTION.	FREE H_2SO_4.
1	1	4.24	0 95
2	2	3.68	1.76
3	3	3.35	2.28
4	4	2.95	2.88
5	5½	2.54	3 49
6	6½	2.35	3.77
7	7½	2 08	4.18
8	9	1.80	4 61
9	10½	1.37	5.25

The next solution experimented upon was one of cadmium chloride, which contained 9.47 per cent of the metal and a total of 11.33 per cent of hydrochloric acid. Cadmium is so similar to zinc that the results could be predicted with reasonable certainty. The following table gives the data from which it may be seen that cadmium sulphide was still being slowly precipitated at the end of eight hours from a solution containing more than ten per cent of free acid.

SERIES IX.

NO. OF EXAMINATIONS.	TIME.	CD. REMAINING IN SOLUTION.	FREE HCl,
1	2	4.00	8.72
2	3	2 96	9 40
3	4	2 42	9 94
4	5	1 81	10 15
5	7	1.75	10.19
6	8	1 64	10.26

In summarizing the results several facts are to be noted. The reactions studied are surprisingly slow, whereas most heavy metals are immediately precipitated by hydrogen sulphide. The precipitation curve, as one would expect, slants rapidly at first, but after passing the gas through the solution two or three hours the curve assumes a direction more and more nearly parallel with the axis of abcissa. The character of the curve, moreover, is independent of the character of the acid. (See Figure 2.)

Agitation hastens the precipitation only very slightly, and it may be assumed that it does not alter the point of equilibrium.

A moderate rise in temperature retards the reaction of hydrogen sulphide and zinc only slightly, and probably

does not greatly influence the point of equilibrium, though the evidence in this regard is not conclusive. Solubility usually increases with temperature, and we should expect

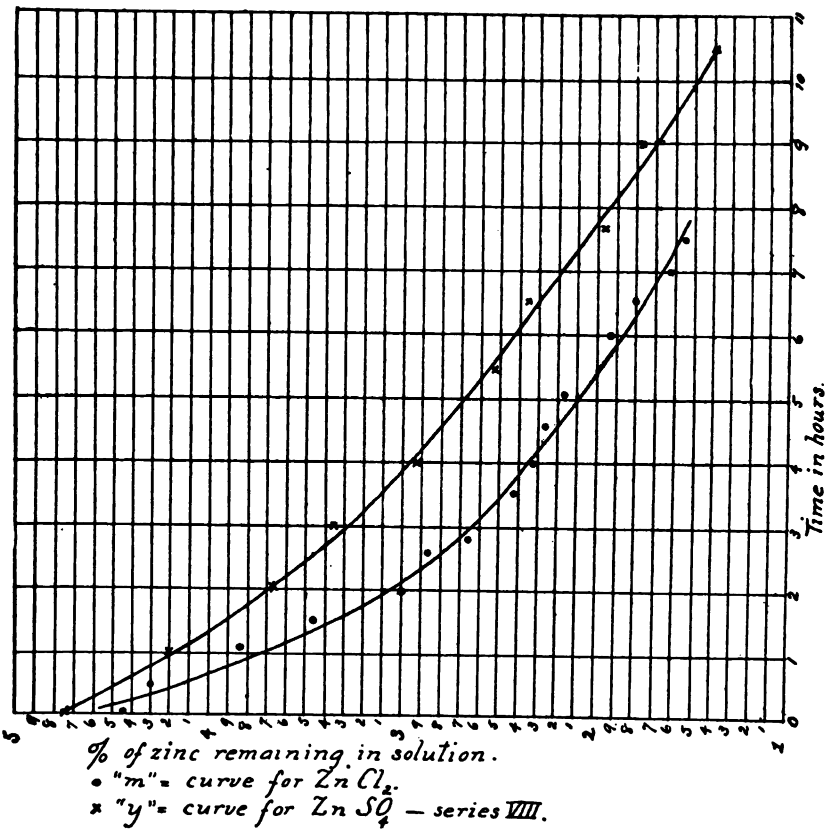


Figure 2.

more zinc sulphide to dissolve in a given time at the higher temperature, and that, therefore, the effect of the reaction,

$$ZnCl_2 + H_2S \rightleftharpoons Zn + 2HCl$$

from left to right would be less in any given period. The decrease in the active mass of hydrogen sulphide at the higher temperature should, leaving change in ionization out of account, contribute to the same result. There are,

however, in such a complex system so many unknown or unmeasurable influences that speculation seems hardly justifiable at this stage of the work.

It is hoped that the foundations have been laid for the more accurate separation of zinc and cadmium through hydrogen sulphide. Every teacher of Chemistry knows how often in analytical work zinc is precipitated with the metals of the copper group and lost, and how often cadmium fails to come down in its proper place in that group. From the data given above it is evident that the long continued action of hydrogen sulphide will precipitate zinc from a solution containing less than about four per cent of free hydrochloric acid. It is also evident that cadmium will not be completely precipitated within a reasonable length of time if the solution contains more than about eight per cent of the same free acid. This leaves a working latitude of only about four per cent of free acid, and the difference becomes practically even less when we take into account the acid set free in the reaction.

The exact conditions necessary to effect the most nearly complete separation of zinc and cadmium at a single precipitation will receive further study.

I wish here to take the opportunity to express my sincere thanks to Dr. W. S. Hendrixson at whose suggestion this work was begun, and to whose kindly aid and advice is largely due any success which this little study may have attained.

DEPOSITIONAL EQUIVALENT OF HIATUS AT BASE OF OUR COAL MEASURES; AND THE ARKANSAN SERIES, A NEW TERRANE OF THE CARBONIFEROUS IN THE WESTERN INTERIOR BASIN.

BY CHARLES R. KEYES.

For a long time it has been known that in Iowa and the neighboring states to the south a break in sedimentation exists at the base of the coal measures. It has been noted in various places in the reports of the Iowa geological survey and reference has been made to it in various other publications. Of its real significance no hint has ever been given.

Recently the correlation of the various formations making up the coal measures has been in progress, and some exceedingly interesting results have been attained. It has been possible to compare the sections in the northern part part of the Western Interior coal field with those of the southern part. The basal horizon of Iowa and Missouri coal measures has been found to belong some 20,000 feet above the Lower Carboniferous or Mississippian. Our Lower Coal Measures are high up in the middle Carboniferous, instead of being near the stratigraphic bottom.

West of the Mississippi river the unconformity at the base of the coal measures is known to extend in a north and south direction from about the north boundary of Arkansas to the southern limit of Minnesota.

From the Mississippi river the rocks have a general dip westward. Over a considerable belt of country west of the great river the juncture of the coal measures with the underlying formations is visible. The width of this belt is from 100 to 200 miles. .How much farther westward it

extends is not known, since the horizon soon is covered too deeply by the overlying strata.

On the highest parts of the Ozark dome in Missouri, the coal measures are still found resting upon the uneven channeled surface of the Lower Carboniferous. South of the southern boundary of Missouri there is no evidence that any break in sedimentation occurs between the coal measures and Lower Carboniferous formations.

How far east of the Mississippi river the unconformable relations exist is not known. However, to the points where the basal line of coal measures dips beneath the eastward sloping strata, the unconformity is everywhere observable.

The plane of unconformity at the base of the coal measures represents clearly an old land surface that was subjected to erosion for a period long enough for the tilted strata to be completely beveled off from the Kaskaskia limestone down to the Cambrian sandstones. During the interval between the deposition of the last of the Lower Carboniferous formations of the region and the coal measures of the upper Mississippi valley enormous denudation had taken place. Heretofore the extent of this erosion has been little appreciated.

The evidence already at hand indicates plainly that the surface on which the coal measures of the upper Mississippi valley were laid down was quite diversified. There were hills and vales, differing in elevation by several hundreds of feet. Some of these have been especially noted by Bain* and other members of the Iowa Geological Survey. There were broad drainage basins and deep narrow gorges†. In some localities even traces of extensive dendritic stream systems are discernible. Some of the most notable of these are those recently described by Shepherd‡ in southwest Missouri.

If we wish to get a general conception of what this old surface relief actually was, we gather something of its real character by comparing it with the relief now existing.

*Iowa Geol. Sur., Vol. I, p. 174, 1893.
†Missouri Geol. Sur., Vol. I, p. 167, 1891.
‡Missouri Geol. Sur., Vol. XII, p. 127, 1898.

The topographic contrasts are certainly nearly as marked in the old as they are to-day over the same area.

The phenomenon under special consideration has been generally regarded as local in its nature; the same, as many unconformities recurring at many places in the coal measures. That it signifies an important sequence of events has never been sufficiently emphasized. That the horizon is really a great hiatus has never been fully considered. That the interval represents a period in the history of the region of much longer duration than it took to form all of the coal measures above it is a phase of the subject never before suggested.

It has lately been shown|| that the present Ozark uplift is of comparatively recent date; that is, Tertiary. In considering the region as it was in Carboniferous times, the dome must be neglected, and the area regarded as forming a lowland plain, the same as the rest of the region was known to be. This is farther indicated by the fact that on the highest parts of the dome remnants of the coal measures are still found on the beveled edges of the older strata.

The oscillation of the Carboniferous shore-lines in the upper Mississippi valley has already been described in detail§. This evidence goes to show that immediately after the Kaskaskia beds were laid down, land existed north of the present Arkansas-Missouri boundary. This was a region of profound and prolonged denudation. South of the line sedimentation continued. The land waste from this northern district was carried into the southern water area.

The northern area, after the close of the early Carboniferous period, being an area of denudation suggests an area to which the waste must have been carried and deposited. There is also suggested a depositional measurement of the erosional period.

In correlating the Iowa and Missouri formations of the coal measures with those of the Arkansas valley a tabular

||Missouri Geol. Sur., Vol. VIII, p. 351, 1895.

§Iowa Geol. Sur., Vol. I, p. 118, 1893.

statement of the sections appears to present the facts most clearly.

SERIES.	IOWA	KANSAS.	INDIAN TERRITORY.	ARKANSAS.
Oklahoman....	....	Oklahoman..	....	....
Missourian.....	Missourian..	Missourian..	Poteau	....
Des Moines.....	Des Moines .	Des Moines..	Cavaniol ...	Poteau* ....
Arkansan	(Wanting)	(Wanting)	Lower C M.	Productive C. M. and Lower C. M,
Mississippian...	Mississippian	Mississippian	Mississippian	Mississippian.

*Not the same as Poteau of Indian Territory.

The thickness of the coal measures of the Mississippi valley is greater than anywhere else in the United States. If two east and west cross-sections, one on the north side of the Ozark dome and the other through the Arkansas valley, are contrasted, the Carboniferous series present about the following measurements:

SERIES.	NORTHERN SECTION.	SOUTHERN SECTION.
Oklahoman..............	1 500	1,500
Missourian.. ...	2,000	1,500
Des Moines.......	500	3,500
Arkansan......	Wanting.	20 000
Mississippian	1,000	1 500

From the foregoing it will be seen that the Lower Carboniferous, or Mississippian series, with its minor divisions, is well defined in northern Arkansas. The Kaskaskia

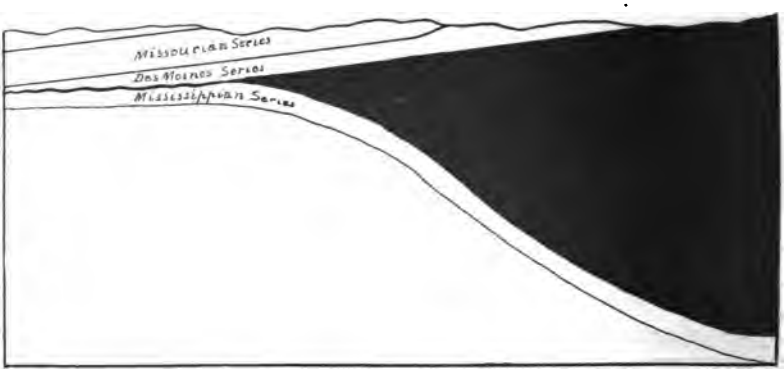


Figure 3.-- Relations of the Mississippi valley members of Carboniferous; solid black represents Arkansan.

terrane is easily identified, passing upward, south of the Boston ridge, into the coal measures.

The basal horizon of the lowest coal measures of Missouri, or Des Moines series, is believed to extend southward and to the south of the Arkansas river to coincide approximately with the Grady coal horizon or the base of the Cavaniol.

With the base of the Des Moines series of Missouri thus located in Arkansas, and the top of the lower Carboniferous well defined it leaves in the south an immense thickness of nearly 19,000 feet of sediments that are in the north wholly unrepresented by deposits. The 19,000 feet of sediments were laid down during the period represented by the stratigraphic break at the base of the northern coal measures.

The magnitude of the hiatus at the base of the coal measures of Iowa, Missouri, and Kansas is readily appreciated when we find a place where sedimentation uninterrupted attained a vertical measurement of 19,000 feet. The period of which there is no measurable record in one part of the region finds in an adjoining district sediments of greater significance than all the coal measures above the break.

Here, then, is a case in which, on the one side of an old shore-line, is the land that suffered profound denudation, and on the other the water area in which sedimentation was carried to a prodigious extent. In point of time the one is the exact equivalent of the other.

Arkansan Series.

If the recent correlations of the different sections of the coal measures in the Western Interior basin can be regarded as even approximate, there exists in the south, below the basal horizon of the Des Moines series, another great series which is now called the Arkansan series.

Heretofore the coal measures of Arkansas have been regarded as anomalous. They present an enormous development as compared with the coal measures of other parts

of the Mississippi valley, and even of other portions of North America.

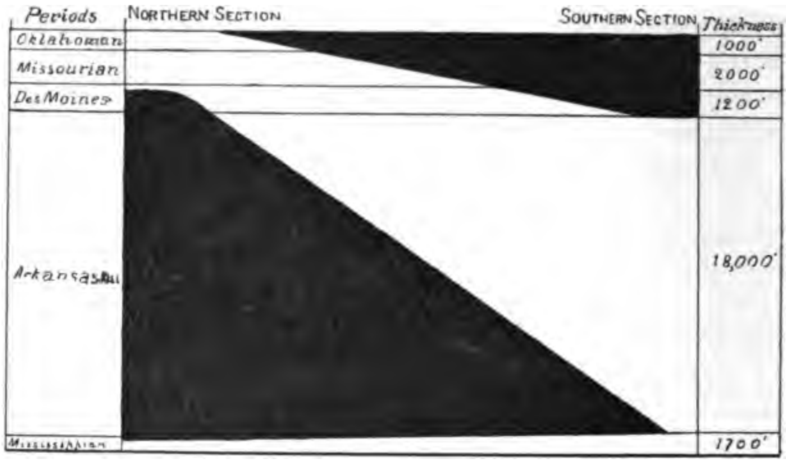


Figure 4.--Shows the relative thickness of the members of the Mississippi valley coal measures north and south.

The thickness of the coal measures of the Arkansas valley as estimated by Branner* is nearly 24,000 feet. If present correlations be correct the highest of these beds in Arkansas are not above the horizon of the Bethany limestone of Kansas. For the deposition of such an enormous sequence there must have existed exceptional conditions. The great development of the coal measures in Arkansas is not widespread, but is confined to a comparatively limited area.

The noteworthy feature in the lithology of the Arkansas coal measures is their make-up of shales and sandstones, with an almost total absence of marked limestones. While this characteristic is remarkable through such an extensive succession, it points clearly to attendant physical conditions that are unmistakable, and that are now known to be in perfect harmony with the historical record of other parts of the region.

The Lower Carboniferous formations are well understood in Arkansas. It is now known that the Boone cherts are

* Am. Jour. Sci., (4), Vol. II, p. 235, 1896.

essentially the Augusta formation of Missouri, and are continuous with that formation as developed in the southwestern part of the last mentioned state. The widely recognized Batesville sandstone has been proved by Weller* without much doubt, to be the equivalent of the Aux Vases sandstone of the Mississippi river region, the basal member of the Kaskaskia formation.

It is now generally agreed that the Boston group of northwestern Arkansas is the equivalent of the Kaskaskia limestone and Chester shales of the Mississippi river. Typical Kaskaskia fossils have been found in the shales of this group in the extreme northwestern corner of the state,* and in the adjoining parts of Missouri.

The exact line of demarkation between the Lower Carboniferous and the coal measures has not been drawn in Arkansas. In the northwestern part of the state Simmonds,* without giving any reasons or data for deducing his conclusions, had regarded a thin shaly limestone (called the Kessler) lying about 78 feet above the Pentremital limestone as the topmost member of the Mississippian. As the shales beneath the Kessler limestone carry thin coal seams with an abundant flora it may be that these as well as the Kessler may eventually prove to belong more properly with the coal measures.

At present it is uncertain just where the separating line between the Mississippian and coal measures should be placed. In the Boston mountains, the stratigraphic succession is apparently unbroken from the Boone cherts (Augusta) upwards. Above the Batesville sandstone the undoubted Kaskaskian beds upwards assume more and more the character of coal measures. Into the latter the former appear to gradually merge. No evidence of unconformable relationships is anywhere noted in this region. Nor do any of the Arkansas geologists mention any facts indicating that a stratigraphic break might exist.

The zone of uncertain age is, however, thin; and the

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*Trans. New York Acad. Sci., Vol. XVI, p. 251, 1897.
*American Geologist, Vol. XVI, pp. 86-91, 1895.
*Arkansas Geol. Sur., Ann. Rept 1888, Vol. IV, p 109, 1888.

basal line of the Arkansas coal measures may be regarded as determined within very narrow limits.

All evidence at hand goes to show clearly that in Arkansas, sedimentation was continuous during the Carboniferous, that enormous deposits were laid down during the period, and that while the beds were being formed there was no marked orogenic movements in the region.

From the north down to the Arkansas line the Des Moines series of the coal measures is well demarked below by the unconformity separating it from all other rocks. Its lowest horizon at this point appears to coincide with the horizon taken as the base of the Cavaniol group of Indian Territory, as traced in detail by Drake. The Cavaniol in turn is correlated in the main with the Upper or Western coal-bearing division or Poteau of Arkansas, which also includes part of the productive coal measures.

The base of the Cavaniol group is now taken to be the Grady coal. This horizon may be considered as limiting above the great Arkansan series of the coal measures. The latter is therefore entirely below the horizon of any part of the Des Moines series as represented in Missouri and farther north.

Notwithstanding its tremendous thickness in central Arkansas the unusual development may be considered as local in nature. From bottom to top it appears to represent practically the same uninterrupted deposition.

Although divisible into a number of subordinate formations it is throughout essentially a compact, homogeneous geological unit. Hence from every standpoint it is thus best considered.

The Arkansas geologists have not yet had opportunity to publish in detail their latest opinions regarding the formations or terranes which they consider as making up the coal measures of the state. Winslow's section, however, is not without interest, and is given below:

Sebastian stage	Boonville stage
Spadra stage	Appleton stage
Norristown stage	Danville stage

The conditions under which the Arkansan series was deposited are of unusual interest. The deposition of such an enormous mass of sediment as is found making up the coal measures of the Arkansas valley must have required some unusual conditions. Branner* has attempted to explain the circumstances as follows:

If we inquire into the reason for the great thickness of coal measures sediment in the Arkansas Valley, I believe it to be found in the drainage of the continent during Carboniferous times. The rocks of this series in Arkansas contain occasional marine fossils, and these marine beds alternate with brackish or freshwater beds whose fossils are mostly ferns and such like land or marsh plants. This part of the continent was, therefore, probably not much above tide level. The drainage from near the Câtskill mountains in New York flowed south and west. The eastern limit of the basin was somewhere near the Archæan belt extending from New England to central Alabama. This Appalachian water-shed crossed the present channel of the Mississippi from central Alabama to the Ouachita uplift, or to a water-shed still farther south and now entirely obliterated and buried in northern Louisiana. In any case the drainage flowed westward through what is now the Arkansas valley, between the Ozark island on the north and the Arkansas island on the south.

The chief objection to this idea is, that we now know that the northern Ozark isle and the Ouachita part of the uplift did not exist as mountainous uplifts in carboniferous times. North of the Missouri–Arkansas line the region was land, to be sure, after the lower Carboniferous marine beds were laid down. South of that line sedimentation continued in deepening waters. The sediments were carried from the north or northeast and dumped off the shore, rapidly building the latter outward.

There may have been a great land area in northern Louisiana, and probably was. If so, what is now the Arkansas river valley was a broad, deep estuary opening out to the west. And the sediments came in from both sides as well as from the head towards the east. The conditions were then similar to those presented now by the Lower Mississippi plain, only the great embayment opened to the west instead of the south.

The present Arkansas valley, however, has probably been formed entirely since Tertiary times, and by a system of

*Am. Jour. Sci., (4), vol II., p. 236, 1896.

drainage in no way dependent upon the Carboniferous drainage. Where the great uplift of Missouri and Arkansas over the northern part embraced by the so-called Ozark isle and the southern part composing the Ouachita mountains were made up of resistant limestones, these yielded less quickly to erosion than the central soft shales, and the Arkansas river which happened in the old peneplain to traverse the central part of the uplifted area was able to cut its way down as fast as the region rose and was thus able to maintain its old course. The present uplift, which is due to one general movement, is now apparently divided into two elevated regions separated by a low valley.

NAMES OF COALS WEST OF THE MISSISSIPPI RIVER.

BY CHARLES R. KEYES.

The coals of commerce acquire names by which they are widely known, and upon which their reputations stand. These names are not geological titles; and coal samples having the same name may, and usually do, come from different mines and even from different horizons. Many analyses and physical tests are made for various industrial purposes from samples taken from the railroad cars, after the latter have reached their destinations.

In the American coal fields, east of the Mississippi river, some coals noted for particular qualities are widely known by special designations. The names have a peculiar value in purely scientific work because the seams are of great areal extent. The geological positions of such coals are inferred as soon as the names are mentioned.

In the Western Interior coal field, numerous names of coals are widely known to the trade; but on account of the rather limited lateral extent of most of the seams their geological horizons cannot be easily inferred. In the following pages is given a list of all of the important coals

known to the trade, together with the first references to the introduction of their names into scientific literature. In this sense their enumeration is as geological titles.

The general geological section of the Carboniferous of the Western Interior coal field is about as follows, the middle three series constituting what is commonly called the coal measures:

SERIES.	TERRANES.	THICKNESS IN FEET.
Oklahoma.	Not here differentiated.	10
Missourian.	Cottonwood limestones.	500
	Atchison shales	30
	Forbes limestones.	150
	Platte shales.	50
	Plattsmouth limestones.	300
	Lawrence shales	35
	Stanton limestones.	100
	Parkville shales.	50
	Iola limestones	75
	Thayer shales	100
	Bethany limestones	
Des Moines.	Marais des Cygnes shales.	200
	Henrietta limestones.	100
	Cherokee Shales	275
Arkansan.	Sebastian.	
	Spadra.	
	Norristown.	
	Boonville.	
	Appleton.	
	Danville.	
	Millstone grit	
Mississippian	Not here differentiated	

The terranes being the stratigraphical units, are the main sub-divisions to be regarded in the present connection. All appear to be more or less well defined throughout the series in which they occur. Over a greater part of the area, the more resistant members—the limestones—form usually prominent topographic features. In this role they appear as conspicuous ridges or eastward facing escarpments, running with many minor sinuosities nearly parallel to one another and separated from each other by lowlands which are worn out on the softer shales. In consequence, the individual layers of the latter are usually so covered with talus and other rock waste, and so easily weathered and

converted into mixed clays and soils, that there is small chance for the shales to crop out. On the whole, the different formations are remarkably well outlined on the surface of the ground, and the stratigraphical bearings of any particular locality are readily made out with ease and confidence.

The layers of the area occupied by the coal measures are, with some minor exceptions, tilted toward the west, and are now beveled. Deformation has not yet been sufficiently marked to change this general arrangement, except perhaps at the extreme southern extremity of the great coal fields, where the Ouachita mountains cross.

Nowhere else is the lenticular character of the strata and terranes better shown than in the coal measures. Inappreciation of this fact has led to great over-estimations of the actual thickness of the coal measures as a whole, and of its several parts. This element of error will be largely overcome when it is more carefully considered that the various formations form a series of limited, interlocking lenses, instead of continuous sheets of nearly uniform thickness over the entire district occupied by the coal-bearing terranes. The slightly tilted and beveled beds, as we find them in the region under consideration, present phenomena comparable to the shingled roof of a house. If, along the surface, the thickness of the various outcropping strata were measured successively and then added together, a very different result would be obtained regarding the thickness than if the measurements were made in a boring. In the case of both the shingles and the tilted strata there would be enormous over-estimates of values. That this is really so in regard to strata was recently shown in central Iowa, where a test cross section was made under very favorable conditions. The added surface measurements gave a figure three times as great as the actual borings.

There are in the so-called coal measures, composing what the geologists of the region now term the Arkansan, Des Moines and Missourian series, fifteen distinctive shale formations, separated in the upper part of the section by extensive limestones. All of these terranes carry coal to

some extent, though in several the amount is so small that it may be neglected altogether, for it is no greater than is found in almost every geological formation. None of the last named have any claim to the title of coal-bearing strata.

One important feature which has been clearly brought out by the recent investigation is the fact that the great workable coal bodies of the Trans-Mississippian region are definitely limited in their stratagraphic extent. By this great restriction in geological range of the coals as compared with that formerly supposed, the figures for the actual available tonnage are, perhaps, not so much affected as are the figures for the areal extent of the district that can now be regarded as a possible producing field.

To present the proposition more clearly, we may tabulate the coal production of the entire region according to the percentages, in each state, that each geological formation, or terrane, supplies.

TERRANE PERCENTAGES OF COAL PRODUCTION.

FORMATIONS.	Iowa.	Missouri	Kansas	Ark.	Ind. Ter.	All
MISSOURIAN SERIES:						
Atchison shales	0.2	....	......	......	......	......
Platte shales	......	......	6.0	......	......	1.2
Lawrence shales	......	.....	0.3	......	......	.....
Parkville shales	......	......	....	......	......	......
Thayer shales	......	......	0.2	......	......	......
DES MOINES SERIES:						
Marais des Cygnes shales	1.0	0.1	0.8	.....	......	0.4
Henrietta formation	15.4	18.5	0.2	......	......	7.0
Cherokee shales	83.4	81 4	92.5	90.0	100.0	91.4
ARKANSAS SERIES	......	.....	......	10.0	......	......

It appears somewhat startling that from the Cherokee division alone should come nine-tenths of the total coal output. Yet this is about the proportion that it will continue to supply in the future. If anything, the Cherokee percentage will increase, rather than diminish, as the Henrietta coals come from a single seam. At least, there appears to be only one seam in a locality belonging to the

Henrietta, but it is not believed that it is everywhere the same continuous bed. At present, however, this median member of the Des Moines series furnishes about 7 per cent. of the total supply. The coal of the Henrietta division lies everywhere very near the base of the formation. Hence, if we should take a few feet of this terrane and add it to the Cherokee, we would have practically 98 per cent. of the entire Trans-Mississippian output of coal north of the Arkansas river coming from the lowermost member of the coal measures of this region—the Cherokee shales.

It is a noteworthy fact that south of the Boston mountains the coal measures thicken enormously, and that the coal horizons, instead of being near the base of the section, are high above the Mississippian limestones. This is believed to be explainable by the fact that a very considerable part of the Arkansas and Indian Territory coal measures are by depositions unrepresented north of the southern boundary of Missouri. In the northern portion of the field the great erosion unconformity, which everywhere is found at the base of the Des Moines series, probably represents the time when, in the south, deposition was going on. This great sequence in Arkansas lying below the horizon of all the Cherokee, as displayed north of the Boston mountains, is perhaps sufficiently important to receive a taxonomic rank equivalent to the Des Moines or the Missourian. The exact upper limiting horizon of this great Arkansan series is not as yet determined.

The thickness of the Cherokee shales may be taken to be about 300 feet. From this measurement they taper out eastwardly to a feather edge. If the total thickness of the coal measures (Des Moines and Missourian series) north of Arkansas are taken at 2,000 feet, the basal one-seventh furnishes 98 per cent. of the whole output.

NAMES OF COALS.

Ardmore coal, lower, Gordon. (Missouri Geol. Sur., Vol. IX, Sheet Rept. No. 2, p. 21, 1894.) In Macon county, Missouri, one of the lower coals of the Cherokee

Beech coal, Marbut. (Missouri Geol. Sur., Vol. XII, pt. ii, p. 348, 1898.) In Howard county, Missouri, a thin seam in the Henrietta division.

Bevier coal, McGee. (Trans. St. Louis Acad. Sci., Vol. V, p. 334, 1888.)

In Macon county, Missouri, the principal seam opened. Cherokee division.

Boicourt coal, Haworth. (Kansas Univ. Quart., Vol. III, p. 305, 1895.) In Linn county, eastern Kansas, near base of Marais des Cygnes division

Brooks coal, Haworth. (Kansas Univ. Quart., Vol. III, p 305, 1895.) One of the seams in the lower portion of the Thayer shales in Wilson county, southeastern Kansas.

Carbon coal. McGee. (Trans. St. Louis Acad Sci., Vol. 5, p. 334, 1888.) In Macon county, Missouri, one of the lower seams in the Cherokee.

Chariton coal, Norwood. (Missouri Geol Sur., Rept. 1873-4, p. 298, 1874.) In Schuyler county, north Missouri, the equivalent of the Mystic seam of Iowa. Henrietta division.

Chariton river coal, Norwood. (Missouri Geol. Sur., Rept. 1873-4, p. 298, 1874.) Same as Chariton coal.

Cherokee coal, Hay. (Trans. Kansas Bd. Ag.ic, 1875, p. 125, 1876) One of the three principal seams of Kansas, in what is now known as the Cherokee shales.

Coal hill coal, Winslow. (Arkansas Geol. Sur., Ann. Rept., 1888, Vol. III, p. 31, 1888) Near middle of Arkansan series in Johnson county, Ark,

Columbus coal, Haworth. (Kansas Univ. Quart., Vol. III, p. 300, 1895.) In the extreme southeast corner of Kansas, a seam lying in the lower part of the Cherokee

Cross coal, Marbut. (Missouri Geol. Sur., Vol. XII, pt. ii, p. 359, 1898.) In Chariton county, Missouri, a thin seam in the Henrietta division.

Douglass county coal, Haworth. (Kansas Univ. Quart., Vol. III, p. 305, 1895) In east-central Kansas, a term given to the seam in the upper part of the Lawrence.

Edwards coal, Winslow. (Missouri Geol. Sur. Vol. IX, Sheet Rept. No. 1, p. 64, 1892) One of the lower seams in Lafayette county, Missouri, lying in the middle part of Cherokee.

Eureka coal, Winslow. (Missouri Geol. Sur., Vol. IX, Sheet Rept. No. 2, p. 53, 1894.) The lowest bed in Macon county, northeast Missouri, and situated in the Cherokee.

Farmington coal, Gordon. (Iowa Geol. Sur., Vol. IV, p 223, 1895.) A small pocket at the base of the Cherokee, in Van Buren county, Iowa.

Fayette coal, Broadhead. (Missouri Geol. Sur., Rept. 1873-4, p 190, 1874.) In Howard county, in central Missouri, a title given to one of the principal seams of the Cherokee.

Fort Scott coal, Saunders (Trans Kansas Bd. Agric., 1872, p. 388, 1873.) Widely applied to one of the chief coals in southeastern Kansas, lying in the Henrietta division.

Fort Scott coal bed, Broadhead. (Missouri Geol. Sur., Rept. 1873-4, p. 133, 1874) Seam in Vernon county, in southwest Missouri, located in the Henrietta division.

Fort Scott red coal, Haworth. (Kansas Univ. Quart., Vol. III, p. 298, 1895.) In southeastern Kansas, a seam near the top of the Cherokee.

Franklin county coal, Haworth. (Kansas Univ. Quart.. Vol. III, p. 305, 1895.) In east-central Kansas, a name applied to several seams occurring near the base of the Lawrence.

Glasgow coal, Broadhead. (Missouri Geol. Sur., Rept. 1873-4, p. 187, 1874) In Howard county, in central Missouri, applied to a seam in the Cherokee.

Grady coal, Chance. (Trans. Am. Inst. Min. Eng., Vol. XVIII, p. 656, 1890.) In basal part of equivalent of Des Moines series, in eastern Indian territory.

Hilltown coal, Norwood. (Missouri Geol. Sur., Rept. 1873-4, p. 293, 1874.) In Schuyler county, in north Missouri, the equivalent of the Mystic seam of Iowa, Henrietta division.

Holden coal, Broadhead. (Missouri Geol. Sur. Iron Ores and Coal Fields, pt. ii, p 168, 1873) A thin seam in the lower part of the Marais des Cygnes division, in western Johnson county, west-central Missouri.

Honey creek coal, Marbut. (Missouri Geol. Sur., Vol. XII, pt. ii, p 78, 1898.) A small seam in Henry county, Missouri, in the upper part of the Cherokee.

Huntington coal, Winslow. (Arkansas Geol. Sur., Ann. Rept.. 1888, Vol. III, p. 28, 1888.) At base of equivalent of Des Moines series in western Arkansas.

Hydraulic limestone bed, Winslow. (Missouri Geol. Sur., Vol. I, p. 133, 1891.) Local name for the Tebo seam in Henry county, Missouri, the position of which is in the median Cherokee.

Independence coal, Haworth. (Kansas Univ. Quart, Vol. III, p. 305, 1895.) One of the seams of Montgomery county, southeastern Kansas, in the lower part of the Thayer shales.

Jordan coal, Winslow. (Missouri Geol Sur., Vol. I, p. 134, 1891.) The lowest bed in Henry and adjoining counties Missouri. Its location is near the base of the Cherokee.

Lacona coal, St. John. (Geology Iowa, Vol I, p. 273, 1870.) In central Iowa applied to a seam near the base of the Marais des Cygnes division.

La Cygne coal, Haworth. (Kansas Univ. Quart., Vol III, p. 305, 1895.) In Linn county, eastern Kansas. at base of the Marais des Cygnes division.

Leavenworth coal, Winslow. (Missouri Geol. Sur, Vol. I, p. 103, 1891.) The principal seam at Leavenworth Kansas, and mined at depths of about 800 feet. It lies in the Cherokee

Lebec coal, Broadhead. (Missouri Geol Sur., Rept. 1873-4, p. 71, 1874.) One of the lower beds in the Cherokee, of Cedar county, southwest Missouri.

Lewis coal, Marbut. (Missouri Geol. Sur., Vol. XII, pt. ii, p. 147, 1898.) A local bed in Henry county, Missouri It lies in the Cherokee division.

Lexington coal, Broadhead, (Missouri Geol. Sur., Iron Ores and Coal Fields, pt. ii, p. 46, 1873.) Along the Missouri river in western Missouri, the principal seam of the Henrietta division.

Lick Creek coal field, Hawn. (Missouri Geol. Sur., 1st and 2d Ann. Repts., pt. ii, p. 123, 1855.) Basal coal of the Cherokee, in Ralls county, in northeast Missouri.

Lonsdale coal, St. John. (Iowa Geol. Sur., Vol. I, p. 282, 1870.) In Guthrie county, Iowa, one of the uppermost seams of the Marais des Cygnes division.

Macon City coal, Gordon. (Missouri Geol. Sur., Vol. IX, Sheet Rept. No. 2, p. 73, 1894.) In Macon county, Missouri, one of the upper seams of the district. Cherokee division.

Marshall coal, St. John. (Iowa Geol. Sur., Vol. I, p. 279, 1870.) In Guthrie county, Iowa, one of the median seams of the Marais des Cygnes division.

Mammoth coal, Broadhead. (Missouri Geol. Sur., Rept. 1873-4, p. 338, 1874.) The thick local pocket in Callaway county, central Missouri. Base of the Cherokee.

Mammoth coal, Marbut. (Missouri Geol. Sur., Vol. XII, pt. ii, p. 147, 1898.) A local bed in the Cherokee division, deposited in Henry county, Missouri.

Marais des Cygnes coal, Swallow. (Kansas Geol. Sur., Prelim. Rept., p. 22, 1866) Main coal of Marais des Cygnes, or Pleasanton formation, in eastern Kansas.

Marais des Cygnes group, Broadhead. (Missouri Geol. Sur., Rept 1873-4, p. 124, 1874.) Name applied in Vernon county, in southwest Missouri, to the upper part of the Cherokee.

Mastodon coal, Broadhead. (Missouri Geol. Sur., Rept. 1873-4, p. 338, 1874.) A limited pocket, 80 feet thick, in Callaway county, Missouri. Base of Cherokee.

Mayberry coal. Chance. (Trans. Am. Inst. Min. Eng. Vol. XVIII, p. 655, 1890.) At top of the equivalent of Des Moines series, in the Choctaw field, in eastern Indian Territory.

McAlester coal, Chance. (Trans. Am. Inst. Min. Eng., Vol. XVIII, p. 657, 1890) Near middle of equivalent of Des Moines series, in Choctaw field, in eastern Indian Territory.

Mendota coal, Winslow. (Missouri Geol. Sur., Vol. I, p. 57, 1891.) This is the Mystic seam of Iowa; and its horizon is in the Henrietta division. Now applied in northeast Missouri, in Putnam county chiefly.

Mormon Ridge coal, Beyer. (Iowa Geol Sur., Vol. IX, p. 218, 1899.) In lower part of Des Moines series, in Boone county, Iowa.

Mound City coal, Haworth. (Kansas Univ. Quart., Vol. III, p. 305, 1895.) In Linn county, eastern Kansas, in median part of Marais des Cygnes division.

Muchakinock coal, Bain (Iowa Geol Sur., Vol IV, p. 361, 1895) One of the most extensive seams in the lower part of the Cherokee, in Mahaska county, Iowa.

Mulberry coal. Broadhead (Missouri Geol. Sur., Rept. 1873-4, p. 168, 1874.) In Bates county, in southwest Missouri, refers to a seam near the base of the Marais des Cygnes division (Pleasanton.)

Mulky coal, Broadhead. (Missouri Geol. Sur., Iron Ores and Coal Fields, pt. ii, p 46, 1873) Title given in Lafayette county, Missouri, to the second principal coal bed.

Mystic coal, Keyes. (Iowa Geol. Sur, Vol. II, p. 408, 1892.) In Appanoose county and adjoining country, the principal coal mined. Henrietta division.

Neodesha coal, Haworth. (Kansas Univ. Quart., Vol. III, p. 305, 1895.) One of the seams in the lower part of the Thayer division, in Wilson county, southeast Kansas.

Nodaway coal, Broadhead. (Missouri Geol. Sur., Iron Ores and Coal Fields, pt. ii, p 398, 1873.) Name applied to the principal coal seam of the Nodaway river valley, in northwest Missouri. It lies about 75 to 100 feet above the base of the Atchison shales.

Norman coal, Chance. (Trans. Am. Inst. Min. Eng., Vol. XVIII, p. 658, 1890.) Near middle of equivalent of Des Moines series, in Choctaw coal field, in eastern Indian Territory.

Oberholz coal, Broadhead. (Missouri Geol. Sur., Iron Ores and Coal Fields. pt. ii, p. 64, 1873.) In Ray county, Missouri, the equivalent of the Lexington seam. Henrietta division.

Osage coal, Owen. (Geol. Sur. Wisconsin, Iowa and Minnesota, p. 138, 1852.) Name applied to very thick seams found on the Osage river and on the Missouri river above the mouth of the Osage, in central Missouri. The seam is really disconnected and consists of very limited pockets of great thickness—75 feet in some cases. They may be considered as situated at the very base of the Cherokee.

Osage coal, Haworth (Kansas Univ. Quart., Vol. III, p. 278, 1895.) In Osage county, Kansas; it appears to lie in the Platte shales.

Osage coal, Saunders. (Trans. Kansas Bd. Agri., 1872, p. 388, 1873.) A name known widely through central Kansas for one of the principal coal seams. Platte shales.

Osage coal field, Hay. (Trans. Kansas Bd. Agri., 1875, p 125, 1876.) The seam is in the Platte shales, in central Kansas.

Osage City coal, Haworth. (Kansas Univ. Quart. Vol. III, p. 304 1895.) Seam in Osage and adjoining counties, in Platte shales.

Osage river coal, King. (Proc. American Asso. Adv. Sci., Vol. V, p. 174, 1851.) In basal part of Cherokee, in central Missouri.

Osage river coal, Johnson. (U. S. 28th Cong., 1st Sess., Senate Doc. 436, p. 539, 1844.) Seam exposed on the Osage river, in central Missouri. Base of Cherokee.

Oswego coal, Crane. (Univ. Geol. Sur Kansas, Vol. III, p. 154, 1898.) In southeast Kansas, a name given to a coal seam that is, perhaps, the same as the Pittsburg seam of the Cherokee shales.

Ouita coal, Winslow. (Arkansas Geol. Sur., Ann. Rept. 1888, Vol. III, p. 34, 1888.) In lower part of Arkansan series, in Pope county, Arkansas.

Panora coal, St. John. (Iowa Geol Sur., Vol. I, p 274, 1870.) One of the lower seams of the Marais des Cygnes, in Dallas county, Iowa.

Philpott coal, Winslow. (Ark. Geol. Sur.. Ann. Rept. 1888, Vol. III, p. 33, 1888.) Near the top of Arkansan series, in Johnson county, Ark.

Pittsburg coal, Haworth. (Univ. Geol. Sur., Kansas, Vol. III, p. 27, 1898.) In the lower part of the Cherokee, in southeast Kansas. It is also called the Weir City-Pittsburg heavy coal, or lower Weir City-Pittsburg seam.

Pleasanton coal, Haworth. (Kans. Univ. Quart., Vol. III, p. 305, 1895.) In Linn county, eastern Kansas, base of Marais des Cygnes division.

Rich Hill coal, Winslow. (Missouri Geol. Sur., Vol. I, p. 146, 1891.) The leading seam mined in Bates county, Missouri. It lies in the Cherokee.

Rulo coal bed, Broadhead. (Missouri Geol. Sur., Iron Ores and Coal Fields, pt. ii, p. 132, 1873.) Name applied in northwest Missouri to a thin seam, best exposed at Rulo, Nebraska which lies near the base of the Atchison shales; now known to be the equivalent to the Nodaway seam.

Secor coal, Chance (Trans. Am. Inst. Min. Eng., Vol. XVIII, p. 658, 1890.) Near middle of equivalent of Des Moines series, in Choctaw field, in eastern Indian Territory.

Shinn coal, Winslow. (Arkansas Geol Sur., Ann. Rept. 1888, Vol. III, p. 35, 1888.) Near base of Arkansan series in Pope county, Arkansas.

Silver Lake coal, Beede. (Trans. Kansas Acad. Sci., Vol. XV. p. 30, 1898) One of the upper coal seams of the lower Waubansee (Atchison) shales. It is mined in Shawnee county, Kansas, at Silver Lake, and also southwest of Topeka.

Spadra coal, Winslow. (Arkansas Geol. Sur., Ann. Rept. 1888, Vol. III, p. 32, 1888) Near middle of Arkansan series in Johnson county, Arkansas.

Spring Creek coal seam, Broadhead. (Missouri Geol. Sur., Rept 1873-4, p. 236, 1874.) Believed to be the same as the Mystic or Mendota coal of Putman county, Missouri, adjoining Sullivan county on the north. It lies in the Henrietta division.

Summit coal, McGee. (Trans. St. Louis Acad. Sci., Vol V, p. 334, 1888.) In Macon county, Missouri, the highe-t seem mined. Upper part of Cherokee.

Tebo coal, Winslow. (Missouri Geol. Sur, Vol. I, p. 134, 1891.) Appellation of the chief seam in Henry county, Missouri. Horizon is middle Cherokee.

Thayer coal, Haworth. (Kansas Univ. Quart., Vol. III, p. 305, 1895.) A seam in the median part of the Thayer shales, in Neosho county, southeastern Kansas.

Topeka coal, Haworth. (Kans. Univ. Quart., Vol. III, p. 278, 1895.) One of the seams in the Platte shales, in Shawnee county, Kansas.

Warrensburg coal, Broadhead. (Missouri Geol. Sur., Iron Ores and Coal Fields. pt. ii, p. 184, 1873) A thin seam in the upper part of the Cherokee division, in Johnson county, Missouri

Wapello horizon, Bain. (Iowa Geol Sur, Vol. IX, p. 99, 1899.) An extensive coal in southeast Iowa, lying in the lower part of the Cherokee..

Waverly coal, Winslow. (Missouri Geol. Sur., Vol. IX, Sheet Rept. No. 1, p. 60, 1892) In eastern Lafayette county, Missouri, the lowest seam mined. Cherokee division.

Wheeler coal, St. John. (Iowa Geol. Sur., Vol. I, p. 276, 1870.) One of the lower coals of the Marais des Cygnes, in Warren county, Iowa.

What Cheer coal field, Bain. (Iowa Geol. Sur, Vol. IV, p. 284, 1895. This coal seam, in Keokuk and Mahaska counties, Iowa, lies very near the base of the Cherokee.

Wier City-Pittsburg View, Haworth and Kirk. (Kansas Union Quart, Vol. II, p. 105, 1894.) In southeast Kansas, the most important seam of the Cherokee.

VOLCANIC NECKS OF PIATIGORSK, SOUTHERN RUSSIA.

BY CHARLES R. KEYES.

(Abstract.)

On the Rostov and Wladikavkas railroad, in southern Russia, there rises out of the flat steppes, a few hours before reaching the last mentioned place, a remarkable group

of steep-sided hills, or mountains, each isolated from the others. The principal town of the region is Piatigorsk, which is about ten miles from the railway station of Mineralniya Vody.

The purpose of referring at this time, to these hills, which reach elevations from 1,500 to 2,500 feet above the plain (figure 5), is to call attention to certain geological phenomena that are unusually well developed; and incidentally to exhibit photographs of the highest mountain peak in Europe, which is nearby.

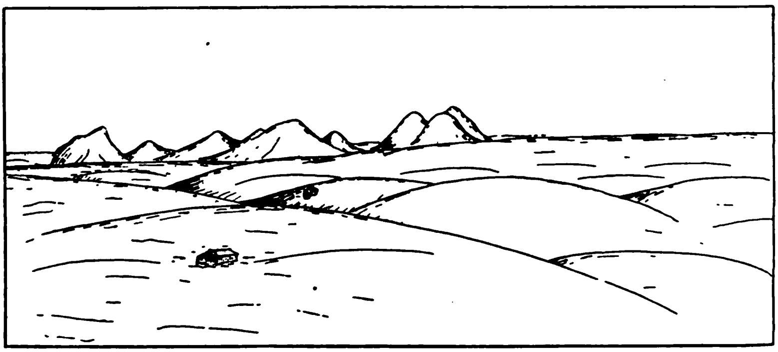

Figure 5. Volcanic necks of Piatigorsk, four miles away.

The plain around Piatigorsk is made up of flat-lying Tertiary deposits. Out of these rise the isolated volcanic mountains, composed mainly of white or gray trachytes. The ash and scoriaceous materials have all been removed, leaving the harder lavas which occupied the pipes of the vents and the central parts of the cones, standing out in abrupt mounds. These vents appear to represent the dying stages of the great outburst which gave birth to the towering volcanic cone of Mt. Elburz, twenty miles distant.

Authorities have long considered Mt. Blanc, in the Alps, to be the highest point in all Europe. Its height above sea-level is placed at 15,780 feet. Recent measurements show that the Caucasus mountains present no less than five peaks, every one of which is more elevated than any part of the Swiss district.

Mt. Elburz is an isolated cone on the north flank of the great Caucasian chain, and rises to a height of 18,526 feet

above the level of the Black sea, or nearly 3,000 feet beyond the highest level of Mt. Blanc. As an elevation Mt. Elburz is a much more striking object of the landscape than the Swiss mountain, for the reason that it rises directly out of the low-lying steppes, the level of which is only a few hundred feet above sea-level, so that it slopes from peak to foot nearly down to the datum plane, while the base of Mt. Blanc is several thousand feet above the sea. Kasbec (16,546 feet), Dikhtau (16,925 feet), Koshtantau (17,096 feet), and Ihkara (17,278 feet) are names of other high peaks in the more central parts of the Caucasus.

Mt. Blanc is visible about 100 miles. Mt. Elburz is said to be visible 200 miles distant. That is to say: If Elburz were located at Kansas City we could from the State House steps on clear days catch glimpses of its snow-crowned top. The photographs were taken on one of the excursions of the International geological congress, and the larger one is probably the best ever obtained of the mountain.

A COMPARISON OF MEDIA FOR THE QUANTITATIVE ESTIMATION OF BACTERIA IN MILK.

BY C. H. ECKLES.

During the past three years the writer has made quantitative estimates of the bacteria in a large number of milk samples. During this work certain facts developed which have very important relations to the accuracy of such estimates.

It was early observed that ordinary peptone agar is entirely unsuited for the purpose as a very small number develop as compared with the same medium to which 2 per cent. of lactose has been added, or with gelatine. It was also observed that when students were given peptone agar to use in isolating milk bacteria, that they very rarely, if ever, found the acid organism, although it often constituted a majority of the entire number present in the milk.

These observations led to the constant use of lactose media when it was desired to make a quantitative estimate or to isolate the acid organism.

A more recent study of the work done by various investigators led to the conclusion that much of the counting of bacteria which has been done is of little value on account of the kind of media used, and the lack of knowledge regarding the relation it bears to the number of organisms developed. It is also evident that mistakes, due to the same cause, have been made in regard to the kind of bacteria most common in milk. The most common mistake has been a failure to recognize that the bacterial flora of milk is composed, as largely as it is, of acid-producing bacteria, mostly of a single species. In order to get a definite result a short series of experiments was recently undertaken with the following objects in view:

First—a. To find how the number of milk bacteria developing on peptone agar compared with number growing on the same media with 2 per cent lactose added. *b.* Same comparison between ordinary peptone gelatin and 2 per cent lactose gelatin. *c.* Same comparison between peptone and lactose gelatin and peptone and lactose agar.

Second.—What effect does the kind of media have on the relative proportion developing, of those causing acid coagulation; those having no effect on milk; and those coagulating by action of an enzyme?

The table which follows shows the data accumulated:

	Dilution.	MEDIA USED.	Total number per c. c.	ACID CLASS.		NO EFFECT ON MILK.		ENYZME PRODUCING.	
				Number per c. c.	Per cent. of whole.	Number per c. c.	Per cent. of whole.	Number per c. c.	Per cent. of whole.
Milk.	6,960	Peptone Agar.....	169,040	....	.....	....	....	....	....
	6,960	Lactose Agar.....	494,160	....	.....	....	....	....	....
Milk.	6,720	Peptone Agar.....	127,680	None....	None	89,370	70	38,304	30
	6,720	Lactose Agar.....	329,280	118,540	36	164,640	50	46,000	14
	6,720	Peptone Gelatin...	255,360	17,875	7	153,216	60	85,120	33
Milk.	1,583	Peptone Agar.....	136,138	12,252	9	103,463	72	20,420	15
	1,583	Lactose Agar.....	1,600,413	928,239	58	576,148	36	96,024	6
	1,583	Peptone Gelatin...	1,302,809	547,179	42	547,179	42	208,459	16
Milk.	3,565	Peptone Agar.....	563,271	None....	None	490,045	87	73,225	13
	3,565	Lactose Agar.....	1,711,200	427,800	25	1,163,600	68	119,784	7
	3,565	Peptone Gelatin...	1,158,625	173,793	15	822,623	71	162,207	14
Buttermilk.	30,000	Peptone Agar.....	1,260,000	138,600	11	970,200	77	151,200	12
	30,000	Lactose Agar.....	26,180,000	8,115,810	31	16,493,000	63	1,570,000	6
	30,000	Peptone Gelatin..	12,320,000	2,587,000	21	8,254,000	67	1,478,000	12
	30,000	Lactose Gelatin...	19,320,000	8,887,200	46	8,887,200	46	1,540,000	8
Whey from Edam cheese	10,960	Lactose Agar.....	19,350,000	230,500	43	8,230,500	43	2,709,000	14
	10,960	Peptone Gelatin..	5,224,000	574,660	11	3,656,000	70	992,500	19
	10,960	Lactose Gelatin...	13,330,000	2,932,600	22	9,597,600	72	799,800	6
Sour milk.	26,500	Lactose Agar.....	28,487,500	21,365,625	75	1,709,250	19	5,412,600	6
	26,500	Peptone Gelatin..	18,671,000	1,867,100	10	1,475,600	80	1,867,100	10
	26,500	Lactose Gelatin...	36,550,000	29,240,000	80	4,386,000	12	2,924,000	8
Milk.	3,900	Lactcse Agar......	9,087,000	4,180,000	46	4,180,000	46	726,960	8
	3,900	Peptone Gelatin..	1,930,500	250,960	13	1,274,130	66	396,400	21
	3,900	Lactose Gelatin...	9,360,000	5,616,000	60	2,527,000	27	1,216,000	13

The peptone gelatin was made up according to common methods, using 10 per cent. gelatine, and making it neutral to phenolphtalien with sodium hydroxide. The peptone agar contained 1.7 per cent. agar, neutralized in the same manner. The lactose media had 2 per cent lactose added after filtering.

It is to be remarked, that the quantitative estimates of the number of bacteria are estimates and not exact determinations, the nearest we can approach to accuracy by present methods. Anyone familiar with such work is aware that

such estimates are only valuable when carried out in large numbers, and that a misleading conclusion may be easily reached from a few isolated experiments. The data presented is conclusive enough that a few general deductions may safely be made.

In separating the colonies on a particular Petri dish into the general classes given, which is based on their relation to milk, a portion of the dish was divided off which contained about the number of colonies desired, usually from 40 to 50. Then every colony which could be found by using a hand lense was taken with a platinum needle and put into a tube of sterile milk. After about three days in the incubator at 35° C the milk cultures were examined. Those which showed a solid acid coagulation, with or without gas, with no dissolving of the curd, were put into the acid class. Those which did not coagulate the milk within that time were classified as producing no effect. It is probable a few of these would show coagulation later, but it would not be of the acid class, and probably all cause more or less complicated chemical changes in the milk without changing the appearance.

Those which coagulated milk without producing acid, or caused the curd to show signs of dissolving after coagulation were classed as enzyme producing. A consideration of the data as bearing upon the points under investigation as stated, shows that regarding the first point, the evidence is very conclusive. In no case does the number developing upon the peptone agar approach the number appearing upon the lactose agar. The greatest difference being found in the buttermilk where the lactose agar shows over twenty times as many as the peptone agar.

The comparison between the peptone and lactose gelatin, although less extreme, is sufficient to show conclusively that the former does not show near as high a development as the latter. As between peptone agar and peptone gelatin the results indicate that the latter will show a considerably greater number of colonies than the former.

The comparisons between lactose agar and lactose gelatin are not sufficient in number to show that either has the advantage in the number of the colonies developed.

The results would indicate that other factors than the media used controls in these comparisons. The acid organisms develop about equally well in the two, but as the bacteria constituting the remainder of the flora vary in species, it is probable that some samples of milk contained those developing best at the lower temperature of gelatin, while others find the higher temperature of the agar most favorable.

Harding* uses lactose agar kept at a temperature of 30° C, in his quantitative work and finds that it gives a higher number than gelatin at room temperature. In regard to the relation of media to the kind of bacteria developed and the kind repressed, one fact stands out clearly. In media without lactose the acid organisms develop very slowly, especially upon agar. In two cases this media showed no acid germs present, while the lactose agar showed that they constituted 36 per cent and 20 per cent of the whole number.

Peptone gelatin shows some acid organisms but comparative few of the number are present. The proportion of acid bacteria developing upon lactose agar and lactose gelatin is much the same. The data shows that all three classes grow in less numbers upon peptone agar than upon other media. The enzyme producing seem to develop rather better as a rule on gelatin than on agar. Those having no effect appear to find the lactose agar the most suitable medium for growth.

It is evident that erroneous conclusions may be drawn, as some investigators have done, from using peptone media for work with milk bacteria, either regarding the number present, or the species represented.

*Bul. 172, New York Exp. Station.

A METHOD OF ISOLATING AND COUNTING GAS PRODUCING BACTERIA IN MILK.

BY C. H. ECKLES.

It is a well known fact that more or less gas producing bacteria are present in almost all ordinary milk. The number present varies with the season of the year and the treatment the milk has received.

This class of ferments is of considerable importance on account of the relation it bears to cheese making.

Practical men have long considered the development of gas during the process of cheese making as a serious impediment to the production of the desired quality. This view has been largely sustained by scientific investigation. The bacteria which produce this gas mostly belong to, or are closely allied to the colon group. The gas is produced from the decomposition of the milk sugar and is generally composed of about one-third carbon dioxide and two-thirds explosive gas, probably hydrogen.

During the past two years the writer has had occasion to determine the number of gas producing germs in a large number of milk samples, and during this work developed the following method: Agar is made up according to the usual methods and treated with a normal solution of sodium hydroxide until neutral to phenolphtalein. After filtering, 2 per cent of lactose is added. The milk is diluted by adding a measured amount to a known volume of sterile water. A sterile pipette is used to measure a small portion of this diluted milk into the melted agar, which is poured into a Petri dish in the usual manner. After it has solidified, a second tube of melted agar is found on top of the first one. This covers all the bacteria added in the first tube. As the growth develops, gas is produced, which

shows itself by forming a bubble in the medium surrounding the colony. As all colonies are below the surface, the number of gas bacteria present in the amount of milk taken will be represented by the number of bubbles appearing. If it is desired to make sub-cultures of the gas bacteria it may be done in the usual manner, with the advantage of being able to secure the right one at once.

One chance for error has been noted. This comes from having too many colonies crowded on the Petri dish, when some of the gas germs will not develop sufficiently to show a bubble. The trouble may be avoided by sufficient dilution. While no exact limit can be set, it seems advisable to have not more than 300 to 500 colonies on a Petri dish.

Although the writer has made no trials, it would appear that this method might be useful in isolating and counting gas producing bacteria in the examination of water suspected of sewerage contamination.

THE TOTAL SOLAR ECLIPSE OF MAY 28, 1900.

OBSERVED AT WADESBORO, N. C.

BY DAVID E. HADDEN.

A total eclipse of the sun is always one of the grandest and most awe-inspiring of all natural phenomena. To the superstitious and unenlightened people of India, Africa and the islands of the sea it is a phenomenon full of terror because of the belief that some great hideous monster is devouring the orb of day, but to the astronomer and scientist it is of such interest and importance that governments, colleges, societies and individuals send out expeditions equipped with costly instruments, over land and sea—literally to the ends of the earth—to locate within the track of the shadow.

Figure 6. Equipment for reviewing the total solar eclipse of May 28, 1900.

Fortunately for American astronomers the eclipse of May 28, 1900, was visible in easily accessible places in our southern states, and the meteorological conditions were all that could be desired, hence the array of telescopes, cameras and other instruments directed upward in an endeavor to unravel old Sol's secrets was probably the finest and most expensive ever erected along the shadow track of a solar eclipse. The total phase of this eclipse began at sunrise in the Pacific ocean west of Mexico and extended in a narrow track, averaging about fifty miles in width, across portions of the southern and southeastern states, leaving our shores near Norfolk, Va., and crossing the Atlantic ocean to Portugal and Spain and ending in southeast Egypt. The only drawback amid all the favoring conditions was the brevity of totality, which within the United States did not exceed 100 seconds, and at Wadesboro was about 90 seconds.

About a year previously I had fully determined to witness this, my first total eclipse, if possible. My original intention was to occupy a location in the state of Georgia, as

cloud observations taken during the month of May in the preceding three years by the Weather Bureau indicated that the chances for clear skies were best in Georgia or Alabama. However, other considerations led me to change my plans and select Wadesboro, only about two weeks before the eclipse day. At this station were also located parties from the Yerkes observatory in charge of Professors Hale and Barnard, the Smithsonian Institution in charge of Prof. S. P. Langley, and a host of assistants; the Princeton observers, nine in number, in charge of Professor C. A. Young; some representatives of the Vassar College observatory, Mr. T. Lindsay, of the Toronto Astronomical Society, and a party of seven ladies and gentlemen from the British Astronomical Association with Rev. J. M. Bacon in charge. In addition to the above a number of persons observed on their own account, among whom was the writer.

I left home on May 22d, and arrived at Wadesboro late in the evening of the 25th, going by way of Chicago, Cincinnati, Knoxville, Tenn., Ashville, and Charlotte, N. C., and am indebted to the C., M. & St. P. railroad for obtaining reduced rates over the various railroads and for other favors.

I was exceedingly fortunate in receiving a cordial invitation from Professor Young and Rev. Bacon to erect my instruments on their observing ground, which was situated about five minutes' walk from the court house on the east side of the borough, on an eminence commanding a clear view toward the eastern horizon for a distance of about fifteen miles; the site chosen was an ideal one and with the assistance of Mr. Maskelyne of England I had my instruments in readiness by Saturday night.

My instrumental outfit consisted of an excellent 4-inch equatorially mounted telescope with solar and other eyepieces, an 8-10 stationary camera containing a 2½ inch portrait lens of 18 inches focus and a 4-5 camera which was mounted on a solar axis and with which I hoped to secure a long exposure for the coronal extensions on a nonhalation plate. In addition I carried several pieces of apparatus, such as diffraction grating, prisms, etc.

The work I had planned to do was:

(1) Note the times of first and last contacts.

(2) Note the colors of the sky as the eclipse progressed.

(3) Expose two plates in the larger camera, giving one, one second exposure, and the other five seconds exposure.

(4) Expose a plate in the smaller camera for about sixty seconds.

(5) Observe the Corona with the naked eye and draw an outline sketch of it from memory after totality was over.

(6) Observe through the telescope the structure of the Corona and polar streamers, including any prominences present.

The weather on Sunday, the day before the eclipse, was warm and sky almost clear. Special Weather Bureau bulletins sent out in the afternoon gave us promise of a clear sky the next morning, which forecast was fully verified, the morning of the 28th being nearly perfect, the sky deep blue and cloudless, with a gentle, cooling breeze from the west. All observers were at their posts early; curiosity seekers and others who had arrived in special excursion trains were kept out of the grounds and all observations carried out as planned, without interruption.

CONTACTS.

The first contact was observed with the telescope and diagonal eye-piece with neutral-tint glass shade, and magnifying power of 78, and was noted at 7h, 36m, 08s, eastern standard time, but as the indentation of the moon's limb at this time was unmistakable, the first contact must have occurred at least 5 seconds earlier.

Second contact and also third were not timed as other work occupied my attention. "Bailey's Beads" were nicely seen just before second contact, and last contact was observed at 10h, 05m, 37s. At this moment the limbs appeared to be in contact and 2 seconds later contact was past.

SKY AND LANDSCAPE COLORS.

Thirty minutes after first contact a perceptible change in the color of the sunlight was noticeable. At 8:20 a. m. the landscape was rapidly darkening, objects on the ground had an orange tint, and faces of persons bore a strange, pallid tinge.

At 8:35 a. m. the sky towards the west and northwest was an intensely deep purple color, and in the east and southeast a pale gray shade. Five minutes later the sky near the zenith was a deep blue purple and light purplish-gray along the far horizon, and during totality the colors in all directions were surpassingly beautiful; above, the sky was deep, purplish-black, while along the distant horizon rose rings of orange and gray, reminding one of a summer sunset. At 8:44 a. m. the shadow bands were observed as narrow, tremulous, quickly moving parallel bars, which continued until totality, and reappeared afterwards.

PHOTOGRAPHS OF THE CORONA.

I watched the disappearing crescent of sunlight through the telescope, using the solar eye-piece until totality began, when I immediately made an exposure of 1 second on a Seed's 26x dry plate in the larger camera; reversed the plate holder and made another exposure of about 5

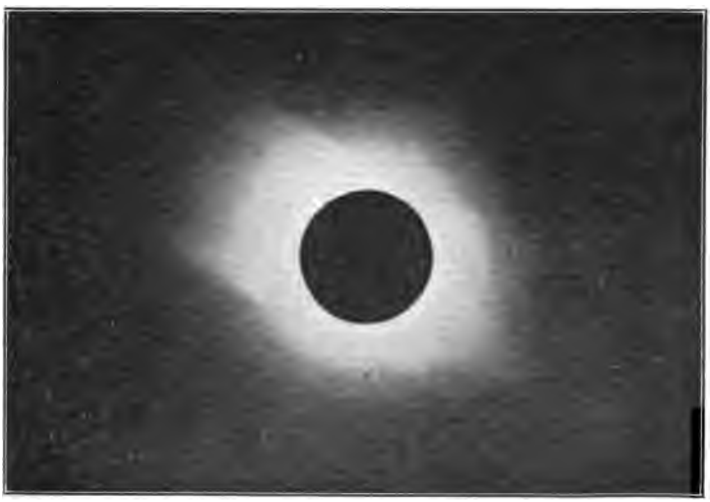

Figure 7. Photograph of the Corona of the solar eclipse of May 28, 1900.

seconds, then opened the shutter of the smaller camera expecting to close it just before totality ended. Unfortunately I forgot it until some 10 seconds afterward, hence the resulting negative was not very satisfactory. The 1

second exposure plate exhibited the inner corona fairly well, also the large prominences on the west and a smaller one on the east limb. The 5-second exposure was quite good and shows the extensions of the Corona to a distance of about twice the sun's diameter on each side of the sun's equator; the polar streamers are also fairly well seen. The Corona on the east side of the sun extended outward nearly in line with the solar equator, in a long, cone-shaped extension with short spurs at each side of its base; the western streamer was in the form of a broad "fish tail" with curved or wing-like brighter extensions on its northwest and southwest sides.

SKETCH OF THE CORONA AFTER TOTALITY.

Shortly after totality was over a number of observers in our party sketched their impressions of the outline of the Corona from memory, and in general there was a close agreement between them, except as to the direction of the

Figure 8. Sketch of Corona made from a series of photographs.

eastern extension, which was nearly in line with the sun's equator instead of either north or south of it as some supposed.

In the accompanying illustration is reproduced a sketch I made shortly after returning home, aided also by the photograph taken with the 2½-inch portrait lens. This sketch represents more clearly the details of the Corona than can be secured with a single photographic exposure.

VISUAL OBSERVATIONS OF THE CORONA.

Fully 45 seconds were consumed after totality commenced in exposing plates, changing plate holders and the eye-pieces of the telescope; the remaining 45 seconds were spent in examining the Corona through the telescope and with the naked eye.

The spectacle was magnificent; to the naked eye the moon appeared not as a flat disc, but a great inky-black globe suspended in the sky with the incomparable glory of the silvery light of the Corona as a background.

Seen through the telescope the soft Coronal radiance was apparently structureless with the beautiful, pinkish-scarlet prominences at its base. The polar rays were strongly suggestive ofelectrical origin and reminded me very much of some fine displays of the Aurora Borealis which I witnessed in the years 1892 to 1894. As the time of the third contact came on, the rich scarlet chromosphere was visible a few moments and like a dissolving view changed to a light pink, when, quickly as a lightning flash the brilliant thin crescent of the photosphere appeared, and the scene was ended.

PRELIMINARY LIST OF THE FLOWERING PLANTS OF ADAIR COUNTY.

BY JAMES E. GOW.

The collections on which this report is based were made chiefly during the summer of the year 1900, some of the work, however, having been done some years earlier. It is the hope of the author that he may in the course of time be able to supply a complete account of the flora of the county—one which will be exhaustive to the last detail. Heretofore such an undertaking has not been possible for him. The work has been done in the intervals of other work and has taken into account chiefly the more common species. It is here presented as preliminary to the more complete report which, it is hoped, will follow it. The grasses and sedges have been purposely reserved for a separate report.

The nomenclature used is that of the sixth edition of Gray's Botany. While more recent systems may have good claims to superiority, the nomenclature of Gray is more generally known than any other, and is better understood by the majority of amateur botanists.

RANUNCULACEAE.

Clematis virginiana L. Not rare.

Anemone cylindrica Gray. Very common.*

A. virginiana L. Not rare.

Thalictrum purpurascens L.

Ranunculus acris L. Very abundant in low grounds.

R. abortivus L

Isopyrum biternatum T. and G.

Aquilegia canadensis L.

Delphinium azureum Ait. Low grounds. Common.

D. exaltatum Ait. Very rare. One specimen in the author's collection is certainly of this species.

*In the case of the more common prairie species no attempt is here made to describe the habitat, or abundance of the species, except in cases where Adair county shows features which are novel and unusual. Most of the species are common and generally known As a rule, woodland species are noted in the text.

Delphinium tricorne Michx. Very common in low grounds.

BERBERIDACEAE.

Berberis vulgaris L. Escaped from cultivation.

PAPAVERACEAE.

Sanguinaria canadensis L. Common in woodlands.

FUMARIACEAE.

Dicentra cucullaria DC. Very common in woods.
Corydalis aurea Willd. Not uncommon.

CRUCIFERAE.

Capsella bursa-pastoris (L) Moench.
Lepidium virginicum L.
Sisymbrium officinale (L) Scop.
Brassica nigra (L) Koch.
B. sinapistrum Boiss.
Arabis Canadensis L.
Cardamine hirsuta L
Nasturtium armoracia (L) Fries.
N. officinale R. Br.
Raphanus sativus L. Escaped from cultivation.

CAPPARIDACEAE.

Polanisia trachysperma T. and G.

VIOLACEAE.

Viola pedata L.
V. blanda Willd. Not common.
V. cucullata Ait.
V. pubescens Ait.

CARYOPHYLLACEAE.

Silene stellata Ait.
S. nocturna L.

PORTULACACEAE.

Portulaca oleracea L.
Claytonia virginica L Common in woodlands.

HYPERICACEAE.

Hypericum ascyron L. Common.

MALVACEAE.

Malva rotundifolia L.
Abutilon avicennae Gaertn. Escaped from cultivation, or introduced in grain seed.

TILIACEAE.

Tilia americana L.

LINACEAE.

Linum usitatissimum. Escaped from cultivation.
L. sulcatum Riddell. Not very common.

GERANIACEAE.

Geranium maculatum L.
Oxalis violacea L.
O. stricta L.

RUTACEAE.

Xanthoxylum americanum Mill. Not common. Found on steep bluffs along the course of middle river.

CELASTRACEAE.

Celastrus scandens L.

VITACEAE.

Vitis riparia Michx.
Ampelopsis quinquefolia Mx. Common in timber.

SAPINDACEAE.

Aesculus glabra Willd.
Acer dasycarpum Ehrb.
Negundo aceroides Moench.

ANACARDIACEAE.

Rhus glabra L.
R. toxicodendron L. Rare, in dense timber.

LEGUMINOSAE.

Baptisia leucantha T. & G.
B. leucophea Nutt.
Lupinus perennis L. Probably fugitive from gardens.
Trifolium pratense L.
T. repens L.
T. hybridum L.
Melilotus alba Lam. Quite common, only in the western half ot the county, where the roadsides are covered with it.
Medicago sativa L.
Amorpha canescens Nutt.
Petalostemon violaceus Michx.
P. candidus Michx.
Tephrosia virginiana Pers.
Astragalus caryocarpus Ker.
A. cooperi Gray. Not common.
Desmodium acuminatum DC. Common on Middle river near northern boundary of county.
D. rigidum D. C.
Lespedeza capitata Michx.
Amphicarpaea monoica Nutt. Tolerably common in woods.
Cassia chamaecrista L. Very abundant.
Gleditschia triacanthos L. Rare.

ROSACEAE.

Prunus Americana Marsh.
P. serotina Ehrh.

Prunus virginiana L.
Geum virginianum L.
Rubus villosus Ait. Escaped from cultivation.
Fragaria vesca L. Escaped from cultivation.
F. virginiana Mill.
Potentilla norvegica L.
P. arguta Pursh.
P. paradoxa
P. canadensis L. Common in low lands.
Agrimonia eupatoria L. Woodlands.
A. parviflora Ait. Woods.
Crataegus coccinea L.
C. tomentosa L.
Rosa arkansana Porter.
Pyrus coronaria L.

SAXIFRAGACEAE.

Ribes gracile Michx. Common in woodlands, and cultivated.

LYTHRACEAE.

Lythrum alatum Pursh. Not very common.

ONAGRACEAE.

Gaura biennis L.
Oenothera biennis L.
Circaea lutetiana L. Not common.

CUCURBITACEAE.

Echinocystis lobata Torr & Gray.

UMBELLIFERAE.

Heracleum lanatum Mx. Low prairie. Common.
Thaspium barbinode Nutt. Banks of streams.
Sium cicutaefolium Gmelin. Common on lowlands.
Zizia aurea Koch. Common on lowlands.
Cicuta maculata L. Common on lowlands.
Osmorrhiza brevistylis DC. Not uncommon on higher land than preceding.
O. longistylis D. C. Same habitat as preceding.
Eryngium yuccaefolium Mx.

CORNACEÆ.

Cornus paniculata, L'Her. Low thickets. Only tolerably common.

CAPRIFOLIACEÆ.

Sambucus canadensis L.
Lonicera glauca Hill. (?)

COMPOSITÆ.

Vernonia fasciculata Mx.
Eupatorium ageratoides L. Rather common in woods.

Liatris scariosa Willd.
L. pychnostachya Mx.
Solidago missouriensis Nutt.
S. speciosa var. angustata.
S. rigida L.
S. lanceolata L.
Aster multiflorus Ait.
Aster lævis L.
Erigeron strigosus Muhl.
Silphium laciniatum L.
S. integrifolium Mx.
S. perfoliatum L.
Ambrosia trifida L.
A. artemisiæfolia L.
A. psilostachya DC. Less common than the two preceding species.
Xanthium canadense Mill.
Heliopsis scabra Dunal.
Echinacea angustifolia DC.
Rudbeckia subtomentosa Pursh.
Lepachys pinnata T. & G.
Helianthus annuus L.
H. grosse-serratus Marteus.
Bidens frondosa L.
Dysodia chrysanthemoides Lag.
Chrysanthemum leucanthemum L. Abundant in pastures, in scattered localities throughout the county. A very troublesome weed.
Tanacetum vulgre L.
Senecio aureus L.
Cacalia tuberosa Nutt.
Arctium lappa L.
Cnicus arvensis Hoffm. Common only in isolated localities, but spreading.
Taraxacum officinale Weber.
Lactuca scariola L. Very abundant as a weed in gardens, as are also the two following species.
L. canadensis L.
Sonchus asper Vill.

LOBELIACEÆ.

Lobelia spicata Lam.
L. syphilitica L.

CAMPANULACEÆ

Campanula americana L.

PRIMULACEÆ.

Steironema ciliatum Raf. (Lysimachia ciliata.)

OLEACEÆ.

Fraxinus americana L.
F. rigidis Mx.

ASCLEPIADACEÆ.

Asclepias tuberosa L.
A. incarnata L.
A. cornuti Dec.
A. verticillata L.
Acerates longifolia Ell.

GENTIANACEÆ.

Gentiana alba Muhl.
G. saponaria L.

POLEMONIACEÆ.

Phlox pilosa L.

HYDROPHYLLACEÆ.

Hydrophyllum virginicum L. Woodlands.
Ellisia nyctelea L. Not very common.

BORRAGINACEÆ.

Lithospermum canescens Lehm.

CONVOLVULACEÆ.

Convolvulus sepium L.
Cuscuta glomerata Choisy. Not common.

SOLANACEAE.

Solanum nigrum L.
S. carolinense L.
S. rostratum Dunal.
Physalis lanceolata Mx.
Datura stramonium L.
D. tatula L.

SCHROPULARIACEAE.

Verbascum thapsus L.
Veronica virginica L.
Catalpa speciosa Warder. (Escaped from cultivation.)

VERBENACEAE.

Verbena stricta Vent.
V. urticaefolia L.
V. bracteosa Mx.

LABIATAE.

Pycnanthemum lanceolatum Pursh. Not common. Woodlands.
Mentha canadensis L. Low prairies—common.
Monarda fistulosa L.
Nepeta cataria L.
N. glechoma Benth.
Scutellaria lateriflora L. Woods.
Brunella vnlgaris L. Woodlands. Common.
Stachys palustris L. Woodlands. Common.

PLANTAGINACEAE.

Plantago major L.

NYCTAGINACEAE.

Oxybaphus hirsutus Sweet.
O. angustifolius Sweet. (?)

ILLECEBRACEAE.

Anychia dichotoma Mx. Woods. Not very common.

AMARANTACEAE.

Amarantus retroflexus L.

CHENOPODIACEAE.

Chenopodium album L.

POLYGONACEAE.

Rumex crispus L. Common everywhere.
R. verticillatus L Tolerably common.
Polygonum aviculare L.
P. ramoisssimum Mx.
P. incarnatum Watson. Sloughs. Only tolerably common.
P. persicaria L.
P. orientale L. Escaped from gardens.
Fagopyrum esculentum Moench. Cultivated species run wild.

EUPHORBIACEAE.

Euphorbia corollata L.
E. maculata L.
E. preslii Guss.

Acalypha virginica var *gracileus* Mueller. Not common.

URTICACEAE.

Ulmus americana L
U. pubescens Walt. (U. fulva Mx.)
Ulmus racemosa Thomas. Reported from the west side of the county, along the course of the Nodaway river, but very doubtful.
Celtis occidentalis L.
Cannabis sativa L. Escaped from cultivation, or adventitious.
Humulus lupulus L. Occasionally fugitive from cultivation in brush and low woody thickets.
Urtica gracilis Ait.
Pilea pumila Gray. Common in all woods.

JUGLANDACEAE.

Juglans nigra L.§
Carya alba Nutt.
C. amara Nutt.

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§*Juglans cinerea* occurs in Madison county, but has not been found in Adair county. The sycamore tree has also been found to the east of the line separating the two counties, but never to the west of it.

¶CUPULIFERAE.

Corylus americana Walt.
Ostrya virginica Willd.
Quercus macrocarpa Mx. High prairie and bluffs along river.
Q. rubra L.
Q. alba L.
Q. coccinea Wang. All four species common along larger streams.

SALICACEAE.

Salix amygdaloides And.
S. alba L.
S. nigra Marsh.
S. Cordata Muhl. Not common. Discovered on Middle river near Madison county line.
Populus monilifera Ait.

ORCHIDACEAE.

Spiranthes gracilis Bigelow. Very rare. Collected by Mr. J. G. Culver on the road between Greenfield and Orient.
Cypripedium candidum Willd. Very rare.
Habenaria leucophea Gray. Once very common. Now almost extinct.

IRIDACEAE.

Sisyrinchium augustifolium Mill.

AMARYLLIDACEAE.

Hypoxis erecta L.

LILIACEAE.

Allium canadense Kalm. Abundant in two or three restricted localities.
Polygonatum biflorum Ell. Low woodlands or brush.
Asparagus officinalis L. Escaped from gardens.
Uvularia granditlora Smith. Woodlands. Not very common.
Erythronium americanum Ker. Woods.
Lillium philadelphicum L.
Trillium nivale Riddell. Woods.
Melanthium virginicum L.
Smilacena racemosa Desf. Woods.

MAYACEAE.

Tradescantia virginica L.

TYPHACEAE.

Typha latifolia L.

ARACEAE.

Arisaema triphyllum Tou.

ALISMACEAE.

Sagittaria variabilis Eng.

¶The birch occurs in Guthrie county but has not been discovered in Adair.

THE JUGLANDACEAE OF IOWA.

BY T. J. AND M. F. L. FITZPATRICK.

Juglandaceae Lindl. Nat. Syst. Ed. 2, 180, 1836.

WALNUT FAMILY.

The walnut family comprises six genera and about 35 species. Only two genera occur in Iowa, namely, Juglans (Walnut) and Hicoria (Hickory), and these two genera are represented by two and five species respectively. From an economic point of view the species are valuable and consequently have been largely utilized until but few specimens of the older forest remain. The younger growth is hardy and will, if spared, eventually yield fair returns.

In general terms the walnut family includes trees with alternate pinnate exstipulate (sometimes stipulate in the bud) leaves and monoecious bracteolate flowers. The staminate flowers are in long-drooping aments with an irregular calyx adnate to the bract and three to many stamens. Pistillate flowers are solitary or clustered with a regular 3–5-lobed calyx adherent to the partially 2–4-celled 1-ovuled ovary; styles 2; fruit a drupe with a fibrous or woody husk and a large 2–4-lobed seed.

JUGLANS. Husk indehiscent; nut furrowed.
HICORIA. Husk 4-valved, dehiscent; nut smooth or angled.

Juglans nigra L. Sp. Pl. 997. 1753. Black Walnut. A tree, 50–100 feet or more high, with furrowed strong-scented brown bark, wood purplish brown, pith in transverse plates, young twigs and petioles puberulent, becoming glabrous with age, and odd-pinnate leaves. Leaflets nearly sessile, serrate, 11–23, ovate-lanceolate, acuminate, mostly glabrous above, pubescent beneath, base sub-cordate or unequal; fruit spherical, 4-celled at the base.

This species occurs in rich woods, flowering in April and May and the fruit ripening in October or November. It is common throughout the state. The wood is heavy, hard, strong, coarse-grained, liable to check in seasoning, and takes a beautiful polish. The wood has been much used in cabinet making, interior finish, for gun stocks, picture frames, etc. For many years walnut logs were a common shipment until the supply was practically exhausted. Oak has now taken the place of the walnut in cabinet making. The corrugated nut is frequently gathered and kept for sale. A decoction of the bark is a frequent domestic dye.

Our specimens are from Johnson, Jefferson, Decatur, and Pottawattamie counties. We have observed the species in Winneshiek, Allamakee, Clayton, Dubuque, Jackson, Scott, Lee, Van Buren, Appanoose, Ringgold, Union, Page, Taylor, Fremont, and Montgomery counties. The State University herbarium has specimens from Story, Calhoun, and Delaware counties. Prof. Pammel reports the species from Woodbury, Hamilton, Boone, and Hardin counties; Mr. Reppert, from Muscatine county; Prof. Bessey, from Fayette and Des Moines counties; Prof. Macbride, from Dubuque, Humboldt, and Dickinson counties; Mr. Gow, from Adair county; Mr. J. P. Anderson, by note, from Lucas county; and Mr. Mills, by letter, from Henry county. In general the black walnut is common throughout the state and represented mostly by the second growth trees.

Parry, in Owen's Geol. Sur. Wisconsin, Iowa, and Minnesota, p. 618; White, Geol. Sur. of Iowa, Vol. 1, p. 138. Bessey, Contr, to the Flora of Iowa in Fourth Report Iowa Agr. Col., p. 118; Arthur, Contr. to the Flora of Iowa, p. 29; Nagel and Haupt, Proc. Davenport Acad. of Natural Sciences, Vol. 1, p. 163; Hitchcock, Trans. St. Louis Acad. of Science, Vol. 5, p. 157; Pammel, Proc. Iowa Acad. of Sciences, Vol. 3, p. 132; Iowa Geol. Sur., Vol. 10, p. 312; Fink, Proc. Iowa Acad. of Sciences, Vol. 4, p. 101; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5. p. 127 and p. 163; Vol. 6, p. 196; Iowa Geol. Sur., Vol. 8, p. 313; Cameron, Iowa Geol. Sur., Vol. 8, p. 198; Macbride, Iowa Geol. Sur., Vol. 4, p. 119; Vol. 7, p. 107; Vol. 10, p. 237 and p.

645; Gow, Proc. Iowa Acad. of Sciences, Vol. 6, p. 62; Rigg, Notes on the Flora of Calhoun County, p. 25; Barnes, Reppert, and Miller, Proc. Davenport Acad. of Natural Sciences, Vol. 8, p. 255; Reppert, Iowa Geol. Sur., Vol. 9, p. 386; Arthur, Flora of Floyd county in History of Floyd County, p. 300; Bot. Gaz., Vol. 7, p. 127.

Juglans cinerea L. Sp. Pl. Ed. 2, 1415, 1763. Butternut. White Walnut. A tree, smaller than the black walnut, bark gray, twigs and petioles viscid-pubescent; leaflets 11-19, oblong-lanceolate, acuminate, base obtuse, rounded or truncate; fruit oblong, pointed, clammy, 2-celled at the base.

The wood of this species has many characters in common with the black walnut and is used in cabinet work, interior finish, etc. The wood differs from the black walnut in being light, soft, of less strength, and of a light brown color. Trees rarely exceed 80 or 90 feet in height and are usually less than two feet in diameter.

Our specimens are from Fayette and Johnson counties. We have observed the species in Jefferson, Allamakee, Winneshiek, Clayton, and Dubuque counties. The state university herbarium contains specimens from Lee, Winnebago, Des Moines, Cerro Gordo, Delaware, Pottawattamie, and Fremont counties. Mr. Reppert reports the species from Muscatine county; Messrs. Nagel and Haupt from Scott county; Professor Bessey from Story county; Professor Macbride from Humboldt county; Mr. Gow from Madison county; and Professor Pammel from Boone and Hardin counties. In general the butternut is frequent all along the eastern border of Iowa and passes through the central portion west to the Missouri river. It appears to be absent in our strictly southern counties. A decoction of the bark is frequently employed in domestic dyeing.

White, Geol. Sur. of Iowa, Vol. 1, p. 138; Bessey, Contr. to the Flora of Iowa in Fourth Report of Iowa Agr. Col., p. 118; Arthur, Contr. to the Flora of Iowa, p. 29; Nagel and Haupt, Proc. Davenport Acad. of Nat. Sciences, Vol. 1, p. 163; Hitchcock, Trans. St. Louis Acad. of Science, Vol. 5, p. 517; Pammel, Iowa Geol. Sur., Vol. 9, p. 243; Vol. 10,

p. 312; Fink, Proc. Iowa Acad. of Sciences, Vol. 4, p. 101; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 127 and p. 163; Cameron, Iowa Geol. Sur., Vol. 8, p. 198; Macbride, Iowa Geol. Sur., Vol. 4, p. 119; Vol. 7, p. 107; Vol. 10, p. 645; Sargent, Forest Trees of N. A., p. 130; Barnes, Reppert, and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 255; Reppert, Iowa Geol. Sur., Vol. 9, p. 386; Arthur, Flora of Floyd county in History of Floyd county, p. 300; Bot. Gazette, Vol. 7, p. 127; Gow, Proc. Iowa Acad. of Sciences, Vol. 6, p. 60.

Hicoria pecan (Marsh.) Britton. Usually a slender tree, 60–100 feet or more high, bark somewhat rough, at length shaggy; leaflets 11–13, oblong-lanceolate, short-stalked, acuminate; staminate aments fascicled; middle lobe of the staminate calyx linear, longer than the oblong lateral lobes; fruit oblong-cylindrical; husk thin, 4-valved; nut oblong-cylindrical, smooth, thin-shelled, 2-celled below; seed edible. *Juglans pecan* Marsh. Arb. Am. 69, 1785; *Carya olivaeformis* Nutt. Gen. 2: 221, 1818; *Hicoria pecan* Britton, Bul. Torr. Bot. club, 15: 282, 1888.

This hickory, commonly known as the pecan, occurs on river bottoms and is infrequent or rare within our limits. The wood of this species is heavy, hard, rather brittle, close-grained, compact, and is reckoned of little value in comparison with the wood of our other species. The nuts, however, are sweet and edible and are an important article of commerce, but Iowa affords very little, if any, of the supply. Dr. White reported the species as belonging to the flora of Iowa.

Professor Pammel reported the species from Woodbury county on the authority of Professor Hitchcock, also from Muscatine and Scott counties; the latter locality on the authority of Mr. Fluke. The State University herbarium has specimens from Muscatine and Louisa counties. Outside of the above four mentioned counties the species is not known to occur within our limits.

White, Geol. Sur. of Iowa, Vol. 1, p. 138; Bessey, Contr. to the Flora of Iowa, p. 119; Arthur, Contr. to the Flora of Iowa, p. 29; Pammel, Proc. Iowa Academy of Sciences,

Vol. 1, pt. 2, 1890–1891, p. 91; Vol. 3, p. 132; Gray's Manual, Ed. 6, p. 468; Britton and Brown, Illus. Flora, Vol. 1, p. 484; Sargent, Forest Trees of N. A., p. 132; Barnes, Reppert, and Miller, Proc. Davenport Acad, of Nat. Sciences, Vol. 8, p. 255; Reppert, Iowa Geol. Sur., Vol. 9, p. 386; Trelease, Seventh Rep. Mo. Bot. Gar., p. 32.

Hicoria minima (Marsh.) Britton. Bitter-nut. Swamp Hickory. A tree, commonly 20–60 feet high; bark close, rough; leaflets 7–9, lanceolate, or oblong-lanceolate, acuminate, sessile, the lateral somewhat falcate, puberulent at first, becoming nearly glabrous; fruit subglobose, narrowly 6-ridged; nut white, somewhat compressed, smooth, not angled, short-pointed, thin-shelled; seed very bitter; husk thin; valves connivent half-way. *Juglans alba minima* Marsh. Arb. Am. 68, 1785; *Juglans sulcata* Willd. Berl. Baumz. 154, 1796; *Carya amara* Nutt. Gen. 2: 222, 1818; *Hicoria minima* Britton, Bull. Torr. Bot. Club, 15: 284, 1888.

The wood of this species is heavy, very hard, strong, close-grained, but checking in drying. The wood is used for fuel, hoops, lumber, etc., The species is common and widely distributed in Iowa, though the greater number of trees are still young. The seed is inedible, being very bitter, sometimes used to adulterate other nuts of the same genus. Our specimens are from Johnson, Jefferson, Ringgold, Montgomery, Pottawattamie, and Shelby counties. We have observed the species in Winneshiek, Appanoose, Taylor, Page, and Fremont counties. The State University herbarium contains specimens from Delaware, Lee, Story, and Cerro Gordo counties. Professor Pammel reports the species from Woodbury, Boone, and Hardin counties; Mr. Reppert from Muscatine county; Professor Fink from Fayette county; Professor Macbride from Humboldt, Dickinson, and Dubuque counties; and Mr. J. P. Anderson, by note, from Lucas county. This species grows best on the lowlands, but frequently occurs on the uplands.

White, Geol. Sur. of Iowa, Vol. 1, p. 138; Bessey, Contr. to the Flora of Iowa in Fourth Report of Iowa Agr. Col., p. 119; Arthur, Contr. to the Flora of Iowa, p. 29; Hitch-

cock, Trans. St. Louis Acad. of Science, Vol. 5, p. 517; Shimek, Bul. Lab. Nat. Hist., S. U. I., Vol. 3, p. 210; Pammel, Proc. Iowa Acad. of Sciences, Vol. 1, pt. 2, 1890-1891, p. 91; Vol. 3, p. 132; Iowa Geol. Sur., Vol. 10, p. 312; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 127 and p. 163; Vol. 6, p. 196; Iowa Geol. Sur., Vol. 8, p. 313; Cameron, Iowa Geol. Sur., Vol. 8, p. 198; Macbride, Iowa Geol. Sur., Vol. 7, p. 107; Vol. 10, p. 238 and p. 646; Barnes, Reppert, and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 256; Reppert, Iowa Geol. Sur., Vol. 9, p. 386.

Hicoria ovata (Mill.) Britton. Shag-bark, Shellbark Hickory. Tree 30-70 feet or more high; bark of the trunk shaggy in narrow plates, young twigs and leaves puberulent, at length glabrous; leaflets usually 5, oblong-lanceolate or obovate, acuminate, finely serrate, sessile, the two lower smaller; staminate aments in 3's, on slender peduncles, at the bases of shoots of the season; middle lobe of the staminate calyx linear, twice the length of the lateral lobes: fruit subglobose, valves of the husk distinct, thick, four; nut white, somewhat flattish, rather thin-shelled, 4-celled below, 2-celled above; seed edible, sweet. *Juglans ovata* Mill. Gard. Dict., Ed. 8, No. 6, 1768; *Carya alba* Nutt. Gen. 2: 221, 1818, not *Juglans alba* L.; *Hicoria ovata* Britton, Bull. Torr. Club, 15: 283, 1888.

This is one of our most important trees, and the wood is much used for wagons, carriages, handles, agricultural implements, etc. The wood is heavy, hard, strong, close-grained and flexible. The species grows in rich upland woods, and is common throughout the state. The nuts are extensively gathered and sold in the market. Fuel is also obtained from this species.

Parry, in Owen's Geol. Sur. Wis., Iowa, and Minn., p. 618; White, Geol. Sur. of Iowa, Vol. 1, p. 138; Bessey, Contr. to the Flora of Iowa in Fourth Report of Iowa Agr. Col., p. 119; Arthur, Contr. to the Flora of Iowa, p. 29; Nagel and Haupt, Proc. Davenport Acad. of Nat. Sciences, Vol. 1, p. 163; Hitchcock, Trans. St. Louis Acad. of Science, Vol. 5, p. 517; Pammel, Iowa Geol. Sur., Vol. 10, p. 312; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p.

127 and p. 163; Iowa Geol. Sur., Vol. 8, p. 313; Cameron, Iowa Geol. Sur., Vol. 8, p. 198; Macbride, Iowa Geol. Sur., Vol. 4, p. 119; Vol. 7, p. 107; Vol. 10, p. 646; Gow, Proc. Iowa Acad. of Sciences, Vol. 6, p. 62; Barnes, Reppert, and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 255; Reppert, Iowa Geol. Sur., Vol. 9, p. 386.

Hicoria laciniosa (Mx. *f.*) Sarg. Big Shag-bark. King-nut. Height about the same and bark similar to the preceding; leaflets 7–9, oblong-lanceolate or obovate, acuminate; staminate aments in 3's, at the base of the shoots of the season; middle lobe of the staminate calyx linear, twice the length of the lateral lobes; fruit oval, 4-ribbed, husk thick, nut large, oblong, pointed at both ends, thick-shelled, yellowish, somewhat angular; seed edible, sweet. *Carya sulcata* Nutt. Gen. 2: 221, 1818, not *Juglans sulcata* Willd., 1796; *Juglans laciniosa* Mx. *f.* Hist. Arb. Am. 1: 199, pl. 8, 1810. *Hicoria sulcata* Britton, Bull. Torr. Club, 15: 283, 1888; *Hicoria laciniosa* Sarg. Mem. Torr. Club, 5: 354, 1894.

The wood is heavy, very hard, tough, strong, flexible, close-grained, and is used for the same purposes as the wood of the preceding species. The fruit is about two inches long or less and about two-thirds as thick. The nut is about an inch in length and is sweet and edible. The species has a rather limited distribution in Iowa, but in some localities it is very common. In Appanoose county, along the Chariton bottoms, are many fine trees; in fact, the species is common along the river throughout its course in the county, and in times past many hundreds of bushels of nuts were gathered and sent to northern and eastern markets. Farther west in Decatur county a number of trees were to be found in the valley of Grand river. We have seen specimens in the State university herbarium from Muscatine, Louisa, and Van Buren counties; Messrs. Nagel and Haupt report the species from Scott county, Professor Shimek from Clinton and Wayne counties, Profesor Macbride doubtfully from Johnson county; and we are creditably informed that the species occurs in Jefferson county.

Nagel and Haupt, Proc. Davenport Acad. of Nat. Sciences, Vol. 1, p. 163; Shimek, Bul. Lab. Nat. Hist., S. U. I., Vol. 3, p. 209; Pammel, Proc. Iowa Acad. of Sciences, Vol. 1, pt. 2, 1890–1891, p. 91; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 167; Iowa Geol. Sur., Vol. 8, p. 313; Macbride, Iowa, Geol. Sur., Vol. 7, p. 107; Britton and Brown, Ills. Flora, Vol. 1, p. 486; Barnes, Reppert, and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 255; Reppert, Iowa Geol. Sur., Vol. 9, p. 386. Trelease, Seventh Rep. Mo. Bot. Gar., p. 40.

Hicoria alba (L.) Britton. White-heart Hickory. Mockernut. Tree growing about 80 feet high, bark not shaggy but rough and close; leaves and twigs persistently tomentose-pubescent, fragrant when crushed; leaflets 7–9, oblong-lanceolate or the upper oblanceolate or obovate, acuminate; staminate aments in 3's, peduncled; middle lobe of the staminate calyx linear, much exceeding the lateral lobes; fruit nearly or quite globose; husk thick; nut grayish white, angled, pointed above, somewhat compressed, thick-shelled, 4-celled below; seeds edible, sweet. *Juglans alba* L. Sp. Pl. 997, 1753; *Juglans tomentosa* Lam. Encycl. 4: 504, 1797; *Carya tomentosa* Nutt. Gen. 2: 221, 1818; *Hicoria alba* Britton, Bull. Torr. Bot. Club, 15: 283, 1888.

The wood of this species has much the same characteristics and the same uses as the two preceding species. The species has an extensive range, being found from Massachusetts and Ontario to Nebraska, south to Florida and Texas. Its range in Iowa is quite limited and confined to the eastern side. Our specimens are from Muscatine county, where we found the species occupying rich uplands, and it appeared to be the common species. The close, rough bark and tomentose leaves and twigs give the species an aspect quite distinct from any other hickory. All the trees which we noticed were small and seemed to be of second growth. We understand that the species occurs in Scott county, and Prof. Pammel has reported it from Johnson county.

Arthur, Contr. to the Flora of Iowa, p. 29; Pammel, Proc. Iowa Acad. of Sciences, Vol. 1, pt. 2, 1890–1891, p. 91;

Barnes, Reppert, and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 255; Reppert, Iowa Geol. Sur., Vol. 9, p. 386; Trelease, Seventh Annual Rep. Mo. Bot. Gar., p. 39.

Hicoria glabra (Mill.) Britton. Pig-nut Hickory. This species has been reported as occurring in Iowa by various authors, but its existence has not been confirmed by subsequent botanists and no specimens are at hand. The fruit of the species is obovoid or ovoid-oblong, about two inches long or less; husk thin; valves tardily dehiscent; nut angled pointed, thin-shelled; seed not edible, bitter. *Juglans glabra* Mill. Gard. Dict. Ed. 8, No. 5, 1768; *Carya porcina* Nutt. Gen. 2: 222, 1818; *Hicoria glabra* Britton, Bull. Torr. Bot. Club, 15: 284, 1888.

Messrs. Nagel and Haupt report the species from Scott county; Prof. Macbride from Allamakee and Johnson counties; and Mr. Gow reports *Carya glabra* Torrey (which is a synonym of the above species) from Adair county, but probably *Carya amara* Nutt. (*Hicoria minima* (Marsh.)-Britton.) was intended.

Nagel and Haupt, Proc. Davenport Acad. of Nat. Sciences, Vol. 1, p. 163; Macbride, Iowa Geol. Sur., Vol. 4, p. 119; Vol. 7, p. 107; Gow, Proc. Iowa Acad. of Sciences, Vol. 6, p. 62.

HYBRIDS.

Mr. Reppert, of Muscatine, has collected in Muscatine county certain forms of hickories that have been published as hybrids. One form was published by Professor Shimek in Bul. Lab. Nat. Hist., S. U. I., Vol. 3, p. 210, as *Carya sulcata X olivæformis.* (*Hicoria laciniosa* X *Hicoria pecan.*) Professor Trelease in the Seventh Report Mo. Bot. Gard., p. 41, says that a supposed hybrid of *Hicoria laciniosa* and *H. pecan* was described by Mr. Fuller in the New York Weekly Tribune, July 9, 1892, as cultivated by Mr. R. M. Floyd, of Cedar Rapids, Iowa. Professor Trelease further considers (p. 39) certain forms contributed by Mr. Reppert and seems to consider them as hybrids of *Hicoria alba* and *H. pecan* (*C. tomentosa* and *C. olivæformis*), and on page 33 other forms as hybrids of *Hicoria*

pecan and *H. minima*. (*C. olivæformis* and *C. amara*.) Barnes, Reppert, and Miller in their Flora of Scott and Muscatine counties mention two hybrids as occurring in the big timber near Muscatine, namely, *Carya olivæformis* X *C. tomentosa* and *Carya olivæformis* X *C. amara*.

BETULACEAE OF IOWA.

BY T. J. AND M. F. L. FITZPATRICK.

BETULACEÆ Agardh, Aphor. 208, 1825.

THE BIRCH FAMILY.

The Birch family as now understood, comprises six genera and about seventy-five species, mostly natives of the northern hemisphere. Some authors include this family with the Oak or Beech family under the name of CUPULIFERAE. The chief distinction is the arrangement of the pistillate flowers. The Birch family has the pistillate flowers in aments while the Oak family has the pistillate flowers subtended by an involucre which becomes a bur or cup in fruit.

The family may be briefly characterized as trees or shrubs, with alternate petioled simple leaves, deciduous stipules, and monœcious flowers. The sterile flowers are in oblong or subglobose pendulous aments; stamens 2–10, inserted at the base of the regular or scale-like calyx; anthers 2-celled. the cells adnate or distinct. Pistillate aments erect, spreading or drooping, spicate or capitate; calyx adnate to the ovary, sometimes wanting. Ovary 1–2-celled, with 1–2 ovules in each cell; style 2-cleft or 2-parted. Fruit a one-celled, one-seeded nut, solitary or clustered, and usually involucrate. In most cases the fruits should be collected for certain identification.

Iowa has within its borders only seven species distributed through five genera. Only one species, the hazel-nut, is distributed throughout the state. All the others have a

decided preference for the eastern half of the state. The alder and the cherry birch are local or quite limited in their distribution, the former occurring in northeastern Iowa, while the latter may be found in central Iowa. The paper birch occurs in northeastern Iowa, a region noted for many species found nowhere else in our state.

* *Staminate flowers, 3—6 together; fruit destitute of an involucre, winged.*

BETULA. Stamens, 2; filaments, 2-cleft; each division with an anther cell.

ALNUS. Stamens, 4; filaments, simple; anther cells, adnate.

** *Staminate flowers solitary; fruit involucrate, wingless*

CORYLUS. Nut enclosed by a leafy involucre.

OSTRYA. Nut at the base of an oblong enclosed bag.

CARPINUS. Nut subtended by a large foliaceous bract.

Betula nigra L. Sp. Pl. 982, 1753. Red or River Birch. A tree, usually thirty to sixty feet high and one to two feet in diameter, with reddish or greenish brown bark, and reddish twigs; peduncles, shoots, and petioles soft downy; leaves rhombic-ovate, acute at both ends, irregularly doubly-serrate, downy beneath when young; nutlet one-seeded, one-celled, broadly winged. *Betula lanulosa* Mx. Fl. Bor. Am. 2, 181.

The species is frequent in the eastern half of the state, less frequent elsewhere. The wood is hard, brown, strong, and of rather light weight. The bark from the branches separates into membranous layers. The species occurs in alluvial soil along rivers. The wood is used for fuel and to some extent for lumber which is used in furniture. The pioneers made ox-yokes from this birch.

Our specimens are from Johnson and Decatur counties. We have observed the species in Allamakee, Clayton, Dubuque, Jackson, Clinton, Wapello, Linn, Appanoose, Jefferson, and Ringgold counties. The State university herbarium has specimens from Delaware, Scott, Muscatine Louisa, Des Moines, and Polk counties. Professor Fink reports the species from Fayette county; Professor Pammel from Hardin county; and Mr. Mills by letter from Henry county.

White, Geol. Sur. Iowa, Vol. 1, p. 138; Arthur, Contr. to the Flora of Iowa, p. 29; Sargent, Forest Trees of North America, p. 161; Pammel, Proc. Iowa Acad. of Sciences, Vol. 1, pt. 2, 1890-91, p. 91; Iowa Geol. Sur., Vol. 10, p. 312;

Fink, Proc. Iowa Acad. of Sciences, Vol. 4, p. 101; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 127, and p. 163; Vol. 6, p. 196; Cameron, Iowa Geol. Sur., Vol. 8, p. 198; Macbride, Iowa Geol. Sur., Vol. 4, p. 119; Vol. 7, p. 107; Vol. 9, p. 152; Vol. 10, p. 647; Reppert, Iowa Geol. Sur., Vol. 9, p. 386; Britton and Brown, Ills. Flora, Vol. 1, p. 509.

Betula lutea Mx. f. Arb. Am., 2: 152, Pl. 5, 1812.

This species is reported by Barnes, Reppert, and Miller from Scott and Muscatine counties in Proc. Davenport Academy of Natural Sciences, Vol. 8, p. 256. They state that the species is common along rivers. They mention no other birch, and as Mr. Reppert had only shortly before reported *Betula nigra* L. as common along streams in Muscatine county in his article, Forest Trees and Shrubs in Muscatine County, published in volume 9 of the Iowa Geological Survey, there seems a probable error. Britton and Brown give the range of this species as Newfoundland to Manitoba, south to North Carolina and Tennessee, mainly in the Alleghanies. In all probability *Betula nigra* L. was the species considered and that *Betula lutea* Mx. f. does not occur in Iowa.

Betula papyrifera Marsh. Arb. Am., 19, 1785. Paper or Canoe Birch. A tree, usually thirty to sixty feet high, usually one to two feet in diameter, with chalky white bark separable into very thin sheets, and brownish twigs; leaves ovate, acuminate, unequally doubly serrate, slender petioled, base obtuse to subcordate, glabrous and green above, glandular and somewhat pubescent beneath.

This species is frequent in rich woods, along streams, in northeastern Iowa. The wood is light, strong, tough, close-grained; mostly used for fuel in Iowa; may be used in the manufacture of spools, shoe-lasts, pegs, turnery, etc. The tough bark separating easily into thin layers is very durable and impervious to water, and has been used by the Indians in the manufacture of canoes and tents.

Our specimens are from Winneshiek county. We have observed the species in Allamakee, Clayton, and Dubuque counties. The State University herbarium has specimens from Delaware county. Professor Fink reports the species

from Fayette county; Professor Macbride from Humboldt county; Professor Pammel from Hardin county; and Messrs. Nagel and Haupt from Scott county. *Betula alba* var. *populifolia* Winchell, in Ludlow's Rep. Black Hills, 67, not Spach, is a synonym, and is the name given by Professor Bessey for this species in his contributions to the Flora of Iowa.

Bessey, Contr. to the Flora of Iowa, p. 119; Arthur, Contr. to the Flora of Iowa, p. 29; Nagel and Haupt, Proc. Davenport Acad. of Nat. Sciences, Vol. 1, p. 163; Pammel, Proc. Iowa Acad. of Sciences, Vol. 1, pt. 2, 1890–1891, p. 91; Iowa Geol. Sur., Vol. 10, p. 312; Fink, Proc. Iowa Acad. of Sciences, Vol. 4, p. 101; Cameron, Iowa Geol. Sur., Vol. 8, p. 198; Macbride, Iowa Geol. Sur., Vol. 4, p. 119; Vol. 10, p. 646; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 127.

Betula lenta L. Sp. Pl. 983, 1753. Cherry Birch. A tree much resembling the cherry, growing forty to sixty feet or more high, with dark brown, smooth bark, which becomes furrowed, but does not separate in layers like our other species, and ovate or ovate-oblong, acute or acuminate, sharply serrulate, short-petioled leaves. Pistillate aments sessile, at the ends of short branches, oblong, proportionately thick, dense.

The range for this species as given by Britton and Brown is Newfoundland to western Ontario, Florida and Tennessee. This places Iowa far west of the supposed range, yet Professor Pammel reports the species from central Iowa, the locality being Steamboat Rock, Hardin county. He says: "Some large trees one foot in diameter occur in moist woods below the sandstone ledges. Much of the birch has been removed. This is very valuable wood and is much used by cabinet makers. Its occurrence in central Iowa is quite unusual."

Pammel, Iowa Geol. Sur., Vol. 10, p. 312.

Alnus incana (L.) Willd. Speckled or Hoary Alder. A shrub, eight to twenty feet high, and about one foot or less in diameter, with glabrous twigs, and pubescent shoots; leaves ovate or oval, acute, usually whitened and downy

beneath; stipules oblong-lanceolate; fruit orbicular, coriaceous-margined. *Betula alnus* var. *incana* L. Sp. Pl. II, Ed. 2, 1394, 1763; *Alnus incana* Willd. Sp. Pl. 4, 335, 1805.

The wood of this species is light brown, close-grained, soft, light, and checks in drying. In New England it is said to be used in the final baking of bricks and in the manufacture of gunpowder.

According to Professor Macbride, this species is common along the Yellow river in Allamakee county. Specimens from Allamakee and Jones counties are in the State university herbarium. Professor Arthur reports the species from Floyd county.

Arthur, Contr. to the Flora of Iowa, p. 29; Flora of Floyd County in History of Floyd County, p. 310; Botanical Gazette, Vol. 7, p. 127; Macbride, Iowa Geol. Sur., Vol. 4, p. 119.

Corylus americana Walt. Fl. Car. 236, 1788. Hazel-nut. A shrub, four to eight feet high, growing in clumps, young shoots hispid, twigs glabrous; leaves ovate, acuminate, serrulate all around, petioled, glabrous above, tomentulose beneath, base obtuse to cordate; involucre of two leaf-like laciniately margined pubescent bractlets, exceeding the oval or oblong nut.

This species makes up much of our thickets. We have observed thickets covering hundreds of acres composed mostly of this hazel with an occasional shrubby bur oak, red haws, plums, etc. Under present conditions the hazel is found along the highway, open upland woods, and uncleared thickets. The only economic value which this species possesses is the use of its fruit which is ripe in August and September. The nuts are small, somewhat striate, compressed, light brown, a half inch or less in length. These nuts have been gathered to a considerable extent and sold in the markets. The difficulty in hulling them has retarded their greater use. A certain species of chipmunk store up quantities of hulled nuts in burrows and some gatherers, knowing the habits of these rodents, systematically rob them of their winter's store much to the profit of the gatherers.

Our specimens are from Johnson, Van Buren, Decatur, Ringgold, Page, and Shelby counties. We have observed the species in Winneshiek, Allamakee, Dubuque, Muscatine, Wapello, Appanoose, Clarke, Adams, Montgomery, and Pottawattamie counties. The State University herbarium has specimens from Winnebago, Emmet, Cerro Gordo, Delaware, Dallas, Webster, Jasper, and Dickinson counties. Professor Bessey reports the species from Story, Fayette, and Des Moines counties; Professor Pammel from Woodbury and Boone counties; Messrs. Nagel and Haupt from Scott county; Professor Macbride from Humboldt county; Mr. J. P. Anderson, by note, from Lucas county; and Mr. Mills, by letter, from Henry county.

Parry, in Owen's Report Geol. Sur. Wis., Iowa, and Minn., p. 618; Bessey, Contr. to the Flora of Iowa, p. 119; Arthur, Contr. to the Flora of Iowa, p. 29; Hitchcock, Trans. St. Louis Acad. of Science, Vol. 5, p. 517; Nagel and Haupt, Proc. Davenport Acad. of Nat. Sciences, Vol. 1, p. 163; Pammel, Proc. Iowa Acad. of Sciences, Vol. 3, p. 132; Iowa Geol. Sur., Vol. 5, p. 237; Vol. 9, p. 240; Fink, Proc. Iowa Acad. of Sciences, Vol. 4, p. 101; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 127; Vol. 5, p. 163; Vol. 6, p. 196; Iowa Geol. Sur. Vol. 8, p. 313; Cameron, Iowa Geol. Sur., Vol. 8, p. 198; Macbride, Iowa Geol. Sur., Vol. 7, p. 107; Vol. 9, p. 152; Vol. 10, p. 238 and p. 647; Reppert, Iowa Geol. Sur., Vol. 9, p. 386; Barnes, Reppert, and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 256; Arthur, Flora of Floyd county, in History of Floyd County, p. 309; Bot. Gaz., Vol. 7, p. 127.

Corylus rostrata, Ait. Hort. Kew., 3: 364, 1789. Beaked hazelnut. Professor Bessey reports this species from Fayette county in his contribution to the Flora of Iowa in the Fourth Report of the Iowa Agricultural College. No other observer has recorded this species as occurring in Iowa, although the state is within the range of the species. We very much doubt if this species has ever been collected in Iowa.

Ostrya virginiana (Mill.) Willd. Hop-hornbeam. Ironwood. A tree, twenty to fifty feet high, with grayish,

furrowed bark; leaves ovate or oblong-ovate; acuminate, sharply and doubly serrate, glabrous above, downy beneath, short-petioled; flowers appearing before or with the leaves; nut small, smooth, ovoid-oblong, sessile at the base of a large inflated oblong closed bag formed from the bractlet, the loosely imbricated involucre hop-like, bristly-hairy at the base. *Carpinus virginiana* Mill. Gard. Dict., Ed. 8, 1768; *Ostrya virginica* Willd. Sp. Pl. 4: 469, 1805.

This species occurs on wooded bluffs and is frequent throughout the state. The flowers appear in April and May and the fruit is ripe in July and August. The wood is dense, strong, durable, and valuable for constructions requiring great strength.

Our specimens are from Winneshiek, Johnson, Henry, Decatur, Union, and Fremont counties. We have observed the species in Allamakee and Clayton counties. The State University herbarium has specimens from Emmet, Calhoun, Cerro Gordo, Webster, Delaware, Lee, and Pottawattamie counties. Professor Pammel reports the species from Harrison, Boone, Hardin, and Woodbury counties; Professor Bessey, from Story and Des Moines counties; Professor Arthur, from Floyd county; Professor Fink, from Fayette county; and Professor Macbride, from Dubuque, Dickinson, and Humboldt counties.

Bessey, Contr. to the Flora of Iowa, p. 119; Arthur, Flora of Floyd county, in History of Floyd County, p. 300; Botanical Gazette, Vol. 7, p. 127; Contr. to the Flora of Iowa, p. 29; Hitchcock, Trans. St. Louis Acad. of Science, Vol. 5, p. 517; Pammel, Proc. Iowa Acad. of Sciences, Vol. 3, p. 132; Iowa Geol. Sur., Vol. 5, p. 237; Vol. 9, p. 240; Vol. 10, p. 312; Fink, Proc. Iowa Acad. of Sciences, Vol. 4, p. 101; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 127 and p. 163; Vol. 6, p. 196; Iowa Geol. Sur., Vol. 8, p. 313; Cameron, Iowa Geol. Sur., Vol. 8, p. 198; Macbride, Iowa Geol. Sur., Vol. 4, p. 119; Vol. 7, p. 107; Vol. 9, p. 152; Vol. 10, p. 238 and p. 647; Reppert, Iowa Geol. Sur., Vol. 9, p. 386; Shimek, Iowa Geol. Sur., Vol. 10, p. 162; Barnes, Reppert, and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 256; Rigg, Notes on the Flora of Calhoun County, p. 25; Sargent, Forest Trees of N. A., p. 158.

Carpinus caroliniana Walt., Fl. Car., 236, 1788. American Hornbeam. Blue Beech. A small tree, ten to thirty feet high, with smooth bluish gray bark; leaves ovate-oblong, acute or acuminate, doubly serrate, base rounded to subcordate, short-petioled, both sides green, glabrous above, somewhat pubescent on the veins beneath; bractlets veiny, 3-lobed at the base, the middle lobe twice the length of the lateral ones, sparingly toothed; fruit a small ovoid nut, which is borne at the base of a large bractlet.

This species is frequent in the northeastern and eastern portions of Iowa. It occurs in woods near streams and blooms in April and May, while the fruit ripens in August and September. The majority of the individuals are but little better than mere shrubs or bushes. The wood is hard, strong, of a light brown color, and is very durable. Owing to the scarcity and small size of the species the wood has but little utility in Iowa, though for small articles, as levers, handles, etc., nothing better could be used.

Specimens in our collection are from Muscatine and Johnson counties. We have observed the species in Allamakee, Clayton, Dubuque, Des Moines, Van Buren, and Wapello counties. The State University herbarium has specimens from Emmet, Delaware, Henry, and Lee counties. Professor Bessey reports the species from Boone county; Professor Pammel, from Hardin county; Professor Fink, from Fayette county; Messrs. Nagel and Haupt, from Scott county; and Professor Macbride, from Humboldt county.

Bessey, Contr. to the Flora of Iowa, p. 119; Arthur, Contr. to the Flora of Iowa, p. 29; Nagel and Haupt, Proc. Davenport Acad. of Nat. Sciences, Vol. 1, p. 163; Fink, Proc. Iowa Acad. of Sciences, Vol. 4, p. 101; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 127 and p. 163; Pammel, Iowa Geol. Sur., Vol. 5, p. 237; Vol. 8, p. 314; Vol. 10, p. 312; Cameron, Iowa Geol. Sur., Vol. 8, p. 198; Macbride, Iowa Geol. Sur., Vol. 4, p. 119; Vol. 7, p. 107; Vol. 9, p. 152; Vol. 10, p. 647; Reppert, Iowa Geol. Sur., Vol. 9, p. 386; Gray's Manual, 6th Ed., p. 474; Barnes, Reppert,

and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 256; MacMillan, Met. Minn. Valley, p. 186.

THE FAGACEAE OF IOWA.

BY T. J. AND M. F. L. FITZPATRICK.

FAGACEAE Drude, Phan., 409, 1879.

OAK OR BEECH FAMILY.

The oak family comprises five genera and 375 species. The family is of wide geographical distribution, and from an economic point of view, of very great value. Four genera occur in the United States, namely, Fagus (the Beech), Castanea (the Chestnut), Quercus (the Oak), and Castanopsis. The number of species and varieties recognized is 87. Of this number 82 belong to the genus Quercus, one each to Fagus and Castanopsis, and three to Castanea. The only genus indigenous to Iowa is Quercus, the oak, and the number of species recognized is 15. The chestnut, *Castanea dentata* (Marsh.) Borkh. has been planted in some communities and seems to thrive. A fine grove of this species may be seen in the southern part of Johnson county and solitary or few trees that are hardy, ornamental, and useful are infrequently observed near dwellings. As the species ranges from Maine to Michigan, south to Tennessee, Iowa may be said to occupy a geographical position suited to chestnut raising. The wood of the species is coarse-grained and very durable. The beech, *Fagus americana* Sweet, ranges from Nova Scotia to Florida, westward to Wisconsin and Texas, but occurs nowhere in Iowa, yet the species might very naturally be expected. The beech belongs to a rather numerous class of species that may be found to the north, east, or south of Iowa, yet refuses to enter within our limits, or if at all, only in very restricted localities in the northeastern or eastern portions of the state.

The oak has been looked upon as the peer of forest trees; aye, even taken as the symbol of strength. Its close, strong fibers enable the tree to resist a thousand storms. Its vitality readily causing a new growth to be rapidly spread over the narrow path riven by the lightning. Some of the species live several hundred years ere storms, fungi, accidents, and natural old age have at last consumed the the tree's vitality and death results.

Let us pass through a native oak grove of eastern Iowa. At first we shall be struck by the remarkable paucity of large trees, though here and there fine ones are seen. Further observation, however, reveals many decaying stumps, clearly indicating the cause of the scarcity. In place of the primeval there are numerous young trees which collectively constitute the so-called second growth. On noticing species we find they bear a rather general numerical relation to each other. Sometimes one species predominating, and again another, so as to receive the distinctive names of white oak, bur oak, or the so-called black oak groves. One particular grove on the uplands is composed largely of scarlet oak (*Q. coccinea* Wang.); the trees are thick set, limby or not, as is convenient for them; stately, thriving or passive as the seasons of average moisture or drought appear. Here and there may be seen a solitary red oak (*Q. rubra* L.), or at best but few individuals, for they seem not to thrive in numbers where the scarlet oak abounds. The bur oak (*Q. macrocarpa* Mx.) fares better, though not many individuals may be counted in close proximity with the scarlet oak, yet passing in certain directions we find the number increasing until we are in a typical bur oak grove. We said we were on the uplands, but we find on passing to the lowlands that the bur oak is there. The trees are large, but the quality of the timber is comparatively poor. The white oak (*Q. alba* L.) has much the same habit as the bur oak. Solitary individuals occurring among the scarlet oaks and in certain places predominating, though as we pass from point to point we may find white oaks mixed with bur oaks along with scarlet oaks, until differentiated by natural causes

into predominant or subordinate numerical positions. Let us pass over to the bluff side next the river, and here we may expect to find a few chestnut oaks (*Q. acuminata* Mx.)-Sarg. As the chestnut oaks we usually find are few and small, we look upon them as curiosities in the oak line. Rarely do we find a Quercitron or black oak (*Q. velutina* Lam.) mixed in our typical oak grove.

Let us pass to southeastern or southern Iowa, and we find the relations of the bur, white, scarlet, and red oak remaining much the same as in eastern Iowa, except that the shingle oak (*Q. imbricaria* Mx.) or laurel oak, as it is called in Iowa, makes itself numerous on the uplands, displacing in many localities the scarlet oak. On the second bottoms we find the swamp white oak (*Q. platanoides* (Lam.) Ludw.) flourishing, and in the swampy portions of the lower bottom the pin oak (*Q. palustris* Du Roi) occurs abundantly. The swamp white oak and the pin oak sometimes intermingle on neutral ground, but not to mutual benefit. Returning to the uplands we find groves of black-jack or barren oak (*Q. marylandica* Muench) growing frequently on rather sterile soil. The trees are small, rough formed, apparently stunted, much branched, so much so that getting wood from these groves is slow and laborious. Infrequently we find a water oak (*Q. nigra* L.) in these black-jack groves. This species occurs along streams and swamps in the eastern portion of the United States, but in Iowa we have seen it only on the uplands. Passing out on the prairie we find many colonies of the ground or scrub chestnut oak (*Q. prinoides* Willd.). The species is small, only two or three feet high, of heavy root, and of no economic value save the acorns, which are stored by the prairie squirrels. The roots are a rather formidable obstacle to the breaking of the sod, taxing the patience of the breaker and the draft team. On the prairie, too, we find the bur oak. Instead of the fine, large trees we have scrubs, only a few feet high, but seemingly thriving, in small colonies, and apparently striving to be the prototype of a future forest.

In central and western Iowa we find the red oak frequently displacing the scarlet oak. The white oak is frequent, along with the bur oak, which is stately or shrubby, according to location. Occasionally a few chestnut oaks occur along the bluffs in central Iowa. In central Iowa is also found the Texan red oak (*Q. texana* Buckley), an unusual find. It will be seen that central and western Iowa have few species as compared with the eastern and southern portions. Forests are more extensive in the eastern portion. The larger rivers of the state are all eastern, and the Father of waters is our eastern border. The forest primeval established itself in a narrow strip along our eastern border, sending out branches of tenuous width up the tributaries. The forests of central and western Iowa are meager because they had to be established in a fire-swept zone and had not reached their fullness ere the advent of civilized man. The problem of forest conditions, especially near the rivers, having been solved in the eastern portion, there was opportunity for the increase of species. But the hardy ones were established first, and others followed. The forests of central and western Iowa had made their beginning. The sturdy species had stood the test on favorable ground, and others were following, but the advent of man changed conditions. He made the the prairie a farm and converted the young forests into heat and building materials.

Passing backward in time for a space of fifty years we find the state but thinly settled and nearly all its inhabitants on the eastern side. There were many oak forests with fine, large oaks. The settler chose the best of convenient size to build his home. The sawmill on being brought and conveniently located was energetically employed in producing building materials to be used in the rising villages or on the farms. Thousands of trees were made into rails to be used in the old-fashioned worm fences. The advent of the railways caused an increase in the demand for oak timber for many years. The timber was rapidly disappearing and many citizens felt apprehensive. But as time goes on conditions change. The uni-

versal application of metals materially checked the strain on the timber resources, so that to-day our oak groves, as a rule, are suffering only from the demands for fuel and fence-posts, along with the greed for more pasture land. The opening of the large coal fields in southern Iowa materially reduces the fuel demand.

The Oak family may be characterized as trees or shrubs, with alternate petioled, pinnately-veined leaves, deciduous stipules, and small monœcious, apetalous flowers. The staminate flowers are in pendulous, sometimes erect or spreading aments, with a 4–7-lobed perianth, and 4–20 stamens. The pistillate flowers are solitary or several together, surrounded by an involucre composed of wholly or partially united bracts, which develop into a bur or cup. Perianth 4–8-lobed, adnate to the ovary. Ovary 3–7-celled; ovules 1–2 in each cell, pendulous, only one in each ovary developing. Represented in Iowa by the genus QUERCUS L. Sp. Pl. 994, 1753.

* Acorns maturing the first year; leaves not bristle-tipped
† Leaves deeply lobed or pinnatifid.

Quercus alba L. Sp. Pl. 996, 1753. White Oak. Bark light gray; leaves oblong or obovate-oblong, green above, smooth, pale or glaucous beneath, short-petioled, sinuate-pinnatifid; lobes linear or oblong, obtuse, entire or lobed, base acute; acorn ovoid-oblong, cup depressed-hemispheric, shallow, about one-third the height of the acorn; scales obtuse, appressed, woolly, at length glabrous, lower ones knotty.

This species occurs in upland woods, and is more or less common throughout the state. The wood is hard, tough, close-grained, of a brown color, and very strong, qualities which give utility and durability. Hence for construction materials the white oak is held in great esteem. The settlers drew from this oak materials for their houses, fences, etc. The trunks which were long and straight made excellent framing timbers, as sills, cross-beams, etc., unequaled rails or posts for fences, clapboards or shingles for roofs. On the advent of the local sawmills many trees were cut

and sawed into lumber. In the line of rail fences the white oak had no competitor for durability. Rails are now in use that have resisted the elements for forty years, though the average life cannot be stated to be so long, but is probably ten or fifteen years shorter. On the building of the railways large quantities of white oak timber were used for piling, bridge material, or ties; many of the ties being fashioned with a broad-ax driven by human power. The primeval trees are nearly all gone. The second growth consists of numerous individuals and constitutes the major portion of our white oak groves. The older trees range from sixty to one hundred feet in height and have a trunk diameter of from three to five feet. The young grove trees are from thirty to sixty feet in height, and are from four to ten inches in diameter. The former are usually much-branched, the branches rather large, while the latter are slender and with few or many small, slender branches. The second growth material gives excellent fuel, posts, small piling, etc.

Our specimens are from Johnson, Van Buren, Appanoose, and Decatur counties. We have observed the species in Winneshiek, Allamakee, Clayton, Jefferson, Wapello, Ringgold, and Union counties. The State University has specimens from Delaware, Louisa, Lee, Dallas, Webster, and Pottawattamie counties. Professor Bessey reports the species from Story and Des Moines counties; Professor Fink, from Fayette county; Professor Pammel, from Boone and Hardin counties; Mr. Reppert, from Muscatine county; Messrs. Nagel and Haupt, from Scott county; Professor Macbride, from Dubuque and Humboldt counties; Mr. Gow, from Adair county; and Mr. Mills, by letter, from Henry county.

White, Geol. Sur. of Iowa, Vol. 1, p. 138; Bessey, Contr. to the Flora of Iowa, p. 119; Arthur, Contr. to the Flora of Iowa, p. 29; Hitchcock, Trans. St. Louis Acad. of Science, Vol. 5, p. 517; Nagel and Haupt, Proc. Davenport Acad. of Nat. Sciences, Vol. 1, p. 163; Fink, Proc. Iowa Acad. of Sciences, Vol. 4, p. 101; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 127 and p. 163; Vol. 6, p. 196; Iowa

Geol. Sur., Vol. 8, p. 314; Gow, Proc. Iowa Acad. of Sciences, Vol. 6, p. 61; Pammel, Iowa Geol. Sur., Vol. 5, p. 237; Iowa Geol. Sur., Vol. 9, p. 240; Vol. 10, p. 312; Cameron, Iowa Geol. Sur., Vol. 8, p. 198; Macbride, Iowa Geol. Sur., Vol. 4, p. 119; Vol. 7, p. 107; Vol. 9, p. 153; Vol. 10, p. 647; Reppert, Iowa Geol. Sur., Vol. 9, p. 386; Barnes, Reppert, and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 256.

Quercus minor (Marsh.) Sarg. Post or Iron Oak. Usually a small tree, with rough, gray bark, and broadly obovate, deeply lyrate-pinnatifid leaves which are dark green above and brown-tomentulose beneath; divisions 3 to 7, sometimes undulate or toothed; fruit sessile or nearly so; cup hemispheric, bracts lanceolate, subacute, slightly squarrose; acorn ovoid, two to three times the length of the cup. *Quercus alba minor* Marsh., Arb. Am. 120, 1785; *Quercus stellata* Wang., Amer. 78, Pl. 6, f. 15, 1787; *Quercus obtusiloba* Mx., Hist. Chen. Am., 1, Pl. 1, 1801; *Quercus minor* Sargent, Gard. and For. 2:471, 1889.

The wood of this species is hard, close-grained, brown, and very durable. The specific gravity of this oak is greater than any other, save one of our species. The small trees make excellent posts for wire fences. The rarity of the species in Iowa prevents its use to even a limited extent. So far as we know, it is found in Iowa only in Appanoose county, where we have observed the species for several years. It grows in dry soil on the upland ridges, where it occurs in small groves. The species is found in Michigan on the north, and southwestward in Texas, and extends as far east as Massachusetts. Professor Arthur includes the species in his catalogue under the name, *Quercus obtusiloba* Mx., but gives no locality.

Arthur, Contr. to the Flora of Iowa, p. 29; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 163.

Quercus macrocarpa Mx., Hist. Chen. Am. 2, Pl. 23, 1801. Mossy-cup or Bur Oak. Tree 100–150 feet or more in height; sometimes shrubby, with gray, flaky, deeply-furrowed bark, the twigs rough or corky-winged; leaves

obovate or oblong-obovate, deeply sinuate-lobed or pinnatifid, grayish, downy beneath; fruit sessile or short-peduncled; cup deep, one-half to quite enclosing the ovoid acorn, the scales thick, pointed, the upper subulate tipped, giving a fringed border.

This species is common in rich woods where it reaches its maximum development. It, however, persists in small groves on the exposed prairie where the trees are often little more than shrubs. It is a hardy tree, and gives valuable timber, though not held in so high esteem as the white oak. Primeval trees are now infrequent, but many are 100 to 150 feet high and four to five feet in diameter. The settlers drew heavily from this oak for rails, posts, lumber, framing timber, and fire wood. The young generation of trees would bid fair in time to equal or surpass their predecessors were it not that far too many find the ever needful woodpile an early resting place.

Specimens before us are from Johnson, Van Buren, Decatur, Ringgold, and Fremont counties. We have observed the species in Winneshiek, Allamakee, Clayton, Dubuque, Scott, Muscatine, Jefferson, Appanoose, Taylor, Page, Union, Adams, Montgomery, and Pottawattamie counties. The State University herbarium has specimens from Emmet, Winnebago, Floyd, Cass, Hancock, Webster, Dallas, Delaware, Louisa, Lee, Jasper, Dickinson, Woodbury, and Lyon counties. Professor Fink reports the species from Fayette county; Professor Bessey, from Story and Des Moines counties; Professor Pammel, from Hamilton, Hardin, and Boone counties; Professor Macbride, from Humboldt county; Mr. Gow, from Adair county; Mr. J. P. Anderson, by note, from Lucas county; and Mr. Mills, by letter, from Henry county, a total of forty-three counties. Doubtless there is not a county in the state that has not this species.

White, Geol. Sur. of Iowa, Vol. 1, p. 138; Bessey, Contr. to the Flora of Iowa, p. 119; Arthur, Contr. to the Flora of Iowa, p. 29; Hitchcock, Trans. St. Louis Acad. of Science, Vol. 5, p. 517; Nagel and Haupt, Proc. of the Davenport Acad. of Nat. Sciences, Vol. 1, p. 163; Pammel, Proc.

Iowa Acad. of Sciences, Vol. 3, p. 132; Iowa Geol. Sur., Vol. 5, p, 238; Vol. 10, p. 313; Fink, Proc. Iowa Acad. of Sciences, Vol. 4, p. 101; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 127 and p. 163; Vol. 6, p. 196; Iowa Geol. Sur. Vol. 8, p. 314; Gow, Proc. Iowa Acad. of Sciences, Vol. 6, p. 61; Cameron, Iowa Geol. Sur., Vol. 8, p. 198; Macbride, Iowa Geol. Sur., Vol. 4, p. 119; Vol. 7, p. 107; Vol. 9, p. 153; Vol. 10, p. 238 and p. 648; Reppert, Iowa Geol. Sur., Vol. 9, p. 386; Shimek, Iowa Geol. Sur., Vol. 10, p. 163; Barnes, Reppert, and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 256.

††Leaves sinuate, crenate, or toothed.

Quercus platanoides (Lam.) Sudw. Swamp White Oak. Tree forty to one hundred feet high; bark gray, flaky; leaves obovate or oblong-obovate, base cuneate and entire, margin coarsely sinuate-crenate, white-downy beneath; acorns ovoid oblong, in pairs on long peduncles; cup hemispheric, scales lanceolate, pubescent, appressed, the upper acute or acuminate. *Quercus prinus platanoides* Lam., Encycl., 1:720, 1783; *Quercus bicolor* Willd., Neue Schrift, Ges. Nat. Fr., Berlin, 3: 396, 1801; *Quercus platanoides* Sudw., Rep. Secy. Agric., 1892:327, 1893.

The wood of this species is denser than the white oak, but not so dense as that of the post oak and is tough, hard, strong, and close-grained. So far as our observations go, trees rarely exceed eighteen or twenty inches in diameter. The wood is valuable for fuel, posts, lumber, etc. The species has a limited range in Iowa, though of frequent occurrence in that range. The small size of our trees prevents its use much beyond posts and fire wood. Our specimens are from Jefferson, Appanoose, Decatur, and Ringgold counties. Professor Pammel reports the species from Lee, Muscatine, and Clayton counties; and Messrs. Barnes, Reppert, and Miller, from Scott and Muscatine counties.

Arthur, Contr. to the Flora of Iowa, p. 29; Pammel, Proc. Iowa Acad. of Sciences, Vol. 1, pt. 2, 1890–1891, p. 91; Fitzpatrick, Iowa Geol. Sur., Vol. 8, p. 314; Proc. Iowa Acad. of Sciences, Vol. 5, p. 163; Vol. 6, p. 196; Barnes,

Reppert, and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 256; Sargent, Forest Trees of N. A., p. 141.

Quercus acuminata (Mx.) Sarg. Chestnut or Yellow Oak. A tree attaining large size; bark gray, flaky; leaves lanceolate or oblong, acute or acuminate, equally and coarsely toothed, slender-petioled, base obtuse or rounded, pale beneath; acorn globose; cup hemispheric, thin, shallow, subsessile; scales ovate, appressed. *Quercus prinus acuminata* Mx., Hist. Chenes Am. No. 5, Pl. 8, 1801; *Quercus muhlenbergii* Engelm., Trans. St. Louis Acad., Vol. 3, p. 391, 1877; *Quercus acuminata* Sarg., Gar. and For., Vol. 8, p. 93, 1895.

This species is frequent in eastern and southern Iowa, preferring rocky bluffs and bottoms. The wood is hard, dense, close-grained, durable, and of much strength. The specific gravity is the greatest of our species. This species gives valuable timber, and has been much used until the major portion of the large trees are all gone. Near Keosauqua are quite a number of large trees still growing, and Professor Pammel reports that fine, large trees are common in the valleys of Boone county. Our specimens are from Johnson, Des Moines, Van Buren, Henry, Appanoose, Decatur, Ringgold, and Fremont counties. We have observed the species in Union, Adams, and Montgomery counties. The State University herbarium has specimens from Jackson, Delaware, and Lee counties. Professor Macbride reports the species from Allamakee county; Professor Fink, from Fayette county; Messrs. Nagel and Haupt, from Scott county; Mr. Reppert, from Muscatine county; and Professor Pammel, from Boone and Clayton counties.

Arthur, Contr. to the Flora of Iowa, p. 29; Hitchcock, Trans. St. Louis Acad. of Science, Vol. 5, p. 518; Nagel and Haupt, Proc. Davenport Acad. of Nat. Sciences, Vol. 1, p. 163; Pammel, Proc. Iowa Acad. of Sciences, Vol. 1, pt. 2, 1890-1891, p. 91; Iowa Geol. Sur., Vol. 5, p. 238; Fink, Proc. Iowa Acad. of Sciences, Vol. 4, p. 101; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 163; Vol. 6, p. 196; Iowa Geol. Sur., Vol. 8, p. 314; Cameron, Iowa Geol. Sur., Vol. 8, p. 198; Reppert, Iowa Geol. Sur., Vol. 9,

p. 386; Macbride, Iowa Geol. Sur., Vol. 4, p. 119; Vol. 7, p. 107; Barnes, Reppert, and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 256.

Quercus prinoides Willd., Neue Schrift, Ges. Nat. Fr. Berlin, 3:397, 1801. Ground Oak. This species much resembles the preceding; usually one to four feet high; leaves oval or obovate, coarsely toothed or undulate, shorter petioled; cups deeper, sessile; scales appressed, ovate or lanceolate; acorn ovoid. *Quercus prinus humilis* Marshall.

This species seems to differ from *Quercus acuminata* (Mx.) Sarg., by its low stature and leaf outline. Our experience indicates that this species has a well developed root system. The roots being comparatively large and much ramified. Small groves of this oak which we have seen grubbed made large heaps of roots, reminding one of brush heaps in clearings. These roots have suggested the common name of ground oak. Wherever this oak occurs there is considerable difficulty in breaking the prairie soil. So far we have observed this species only in Appanoose and Decatur counties, but in those counties it was a common species in dry prairie soil. Mr. J. P. Anderson informs us that it occurs in Lucas county. No doubt the species occurs in many of our southern counties. Dr. Vasey reports the species from Iowa.

Vasey, Am. Ent. and Bot., Vol. 2, p. 282; Bessey, Contr. to the Flora of Iowa, p. 119; Arthur, Contr. to the Flora of Iowa, p. 29; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 163; Iowa Geol. Sur., Vol. 8, p. 314.

** Leaves bristle-tipped; acorns maturing the second year.

† Leaves deeply lobed or pinnatifid.

Quercus rubra L., Sp. Pl. 996, 1753. Red Oak. This species may be characterized as a large tree with reddish, coarse wood; leaves mostly oval in outline, deeply lobed, sinuses rounded, lobes somewhat triangular-lanceolate, remotely coarsely-toothed, pubescent when young, becoming mostly glabrous; acorn ovoid, one-fourth immersed; cup saucer-shaped, sessile or subsessile; scales ovate, obtuse

or the upper acute, appressed. *Quercus ambigua* Mx., f. Hist. Arb. Am., 2, 120, Pl. 24, 1812.

The red oak is a common tree of the upland woods, flowering in May and June, and ripening its acorns in October or November. With us individual trees rarely measure four feet in diameter, and the majority range from two to three feet. The bark is dark gray, and but slightly roughened on the branches, but is rarely deeply furrowed and darker colored on the trunk. The tree is a rapid grower, but gives coarse-grained wood from which inferior lumber may be sawed, or when dry, a rapid burning fire wood giving considerable heat may be had. Some use has been made of this oak for certain kinds of furniture. In the days of board fences this oak was taken by the farmers to local mills and made into six or eight-inch width lumber for fence material. The users claimed that the lumber from this species was less liable to warp than other available kinds. A limited use of the red oak for fence posts showed early decay of the portions in contact with the soil. This oak does very well for foundation piling.

The species ranges west of our limits to Kansas and Texas and eastward to Nova Scotia. Within our limits the primeval individuals have been mostly removed, but a sturdy second growth has taken their places. Our specimens are from Johnson, Appanoose, Decatur, Ringgold, Union, Page, Fremont, and Pottawattamie counties. We have observed the species in Winneshiek, Allamakee, Clayton, Wapello, Lee, Van Buren, Taylor, and Montgomery counties. The State University herbarium has specimens from Winnebago, Cerro Gordo, Dallas, Louisa, Webster, Emmet, and Delaware counties. Professor Macbride reports the species from Humboldt, Dickinson, and Dubuque counties; Professor Pammel, from Woodbury, Hardin, and Boone counties; Messrs. Nagel and Haupt, from Scott county; Professor Fink, from Fayette county; Professor Bessey, from Des Moines county; Messrs. Barnes, Reppert, and Miller, from Muscatine county; Mr. Gow, from Adair county; Mr. Mills, by letter, from Henry county; and Mr. J. P. Anderson, by note, from Lucas

county, a total of thirty-seven counties. In all probability the red oak occurs in every county in Iowa.

Bessey, Contr. to the Flora of Iowa, p. 119; Arthur, Contr. to the Flora of Iowa, p. 29; Hitchcock, Trans. St. Louis Acad. of Science, Vol. 5, p. 518; Nagel and Haupt, Proc. Davenport Acad. of Nat. Sciences, Vol. 1, p. 163; Pammel, Proc. Iowa Acad. of Sciences, Vol. 3, p. 132; Iowa Geol. Sur., Vol. 9, p. 240; Vol. 10, p. 313; Fink, Proc. Iowa Acad. of Sciences, Vol. 4, p. 101; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 128 and p. 164; Vol. 6, p. 196; Iowa Geol. Sur., Vol. 8, p. 314; Gow, Proc. Iowa Acad. of Sciences, Vol. 6, p. 61; Cameron, Iowa Geol. Sur., Vol. 8, p. 198; Macbride, Iowa Geol. Sur., Vol. 4, p. 119; Vol. 7, p. 107; Vol. 9, p. 153; Vol. 10., p. 238 and p. 648; Reppert, Iowa Geol. Sur., Vol. 9, p. 387; Barnes, Reppert, and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 256; Sargent, Forest Trees of N. A., p. 148.

Quercus palustris DuRoi, Harbk., 2:268, Pl. 5, f. 4, 1772. Pin Oak. Leaves long-petioled, ovate, deeply pinnatifid, sinuses broad and rounded, lobes divergent, remotely coarsely toothed; acorn ovoid, one-third immersed; cup saucer-shaped, scales triangular ovate, acute or obtuse, appressed.

This species, commonly known as the swamp or pin oak, usually occurs in groves on river bottoms, often in swampy soil. The grove trees are tall, slender, and but little branched. Solitary trees in the open are much branched; the branches are long, slender, spreading, horizontal, or even drooping. The wood was used somewhat by the early settlers for rails, though inferior for the purpose; also, the long, slender trunks, when of proper size, were readily converted by a skillful woodman with a broad-ax, into framing timber for barns and other buildings. When properly seasoned and used for inside material the pin oak does very well. For wood or construction material requiring resistance to the elements, this species furnishes a poor quality.

In Iowa the pin oak has a very limited range. Our specimens are from Muscatine, Lee, Appanoose, and Decatur counties. The State University has a specimen from

Louisa county. Professor Macbride reports the species from Johnson county; Professor Bessey, from Des Moines county; and Messrs. Barnes, Reppert, and Miller, from Scott county. Thus it will be seen that there is a crescent distribution of this species in Iowa, the localities all being southeastern. The species ranges northward to Wisconsin, southward to Arkansas, eastward to Massachusetts and Delaware.

Bessey, Contr. to the Flora of Iowa, p. 119; Arthur, Contr. to the Flora of Iowa, p. 29; Pammel, Proc. Iowa Acad. of Sciences, Vol. 1, pt. 2. 1890-1891, p. 91; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 164; Iowa Geol. Sur., Vol. 8, p. 314; Reppert, Iowa Geol. Sur., Vol. 9, p. 387; Macbride, Iowa Geol. Sur., Vol. 7, p. 107; Barnes, Reppert, and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 257.

Quercus texana Buckley, Proc. Phila. Acad., 1860:444, 1860. Texan Red Oak. This oak is very similar to *Quercus palustris* DuRoi, becoming a large tree; bark reddish-brown, with broad ridges; leaves obovate in outline, bright green above; paler and with tufts of wool in the axils beneath, deeply pinnatifid into 5-9 triangular or oblong lobes which are entire or coarsely few-toothed, the lobes and teeth bristle-tipped; acorn ovoid, 2-3 times the height of the deeply saucer-shaped cup; scales obtusish or acute, appressed.

The Texan red oak we have not seen. We include it on the authority of Professor Pammel, who states that it occurs at Webster City, Hamilton county. Britton and Brown refer the species to Iowa.

Pammel, Iowa Geol. Sur., Vol. 5, p. 238; Britton and Brown, Illust. Flora, Vol. 1, p. 517.

Quercus coccinea Wang., Amer. 44, p. 4, f. 9, 1787. Scarlet Oak. Becoming a large tree; bark internally reddish or gray; leaves deeply pinnatifid, glabrous and white green above, pale and somewhat pubescent in the axils of the veins beneath, becoming scarlet in autumn; acorn ovoid or ovoid-globose, one-half or more immersed; cup hemis-

pheric or top-shaped, scales triangular-lanceolate, appressed or the upper slightly squarrose, glabrate.

In eastern Iowa this oak is one of the principal trees of the young upland woods. The trees usually run from six to eighteen inches in diameter and twenty-five to forty feet high. Large trees are infrequent, owing to the fact that they have been removed and the time is too short since the prairie fires have been stopped or since the primeval trees have been destroyed for the new trees or the second growth ones to attain any considerable size. The wood is as heavy as the white oak, but not so strong or durable, and is coarse-grained. This oak makes up the bulk of the cord wood on the market in those portions o the state where coal is not a local output. The farmers also draw their supplies of firewood from the young groves of this species, especially since much has been winter-killed during the unseasonable winter of 1898–'99 and was seasoned standing. For the wood market the long, slender trees, the prevailing form in the groves, readily yields to the woodman's ax to form the conventional market wood. For the best results, the tree, if growing, should be felled about a year before market time, cut into four-foot lengths, and if necessary, split to convenient sizes and corded. When the wood is dry it is then delivered on the market to the consumers. The final preparation consists in sawing the cord sticks twice and splitting to convenient sizes. When dry the wood readily burns and gives much heat, but is not reckoned as a lasting wood. In those portions of the state where coal is an output this oak is much used for coal props. The young trees are selected and prepared in the same manner as in making cord wood, except the length of the pieces is about three and a half feet, but varies according to the thickness of the coal vein. These pieces having the ends sawed transversely are placed upright in the coal mines as the coal is removed to prevent the falling of the roof of the mine. In the rural districts a limited use of the oak for fencing may be observed, but such fences are short lived. The scarlet oak is sometimes used for foundation piling.

The flowers appear in May and June, and the acorns ripen in September and October. Within Iowa the species is widely distributed. The species ranges northward into Minnesota, southward into Missouri, eastward to Maine, but apparently not to the westward of Iowa. Our specimens are from Johnson, Appanoose, Decatur, Ringgold, Fremont, and Pottawattamie counties. We have observed the species in Allamakee, Dubuque, Jackson, Scott, and Taylor counties. The State University herbarium contains specimens from Delaware county. Professor Fink reports the species from Fayette county; Mr. Reppert, from Muscatine county; Professor Hitchcock, from Story and Blackhawk counties; Professor Macbride, from Humboldt county; and Mr. Mills, by letter, from Henry county.

Arthur, Contr. to the Flora of Iowa, p. 29; Hitchcock, Trans. St. Louis Acad. of Science, Vol. 5, p. 518; Fink, Proc. Iowa Acad. of Sciences, Vol. 4, p. 101; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 128 and p. 164; Vol. 6, p. 196; Iowa Geol. Sur., Vol. 8, p. 314; Cameron, Iowa Geol. Sur., Vol. 8, p. 198; Macbride, Iowa Geol. Sur., Vol. 4, p. 119; Vol. 7, p. 107; Vol. 9, p. 153; Vol. 10, p. 648; Reppert, Iowa Geol. Sur., Vol. 9, p. 387; Sargent, Forest Trees of N. A., p. 148.

Quercus velutina Lam., Encycl., 1:721, 1783. Black Oak. Quercitron. This species very much resembles *Quercus coccinea* Wang.; the outer bark is dark brown, rougher, the inner bright orange; leaves pinnatifid or lobed to beyond the middle, brown-pubescent or stellate-pubescent when young, glabrous when mature, dull green above, pale green and usually pubescent on the veins beneath, leaf-lobes triangular-lanceolate or broad-oblong, usually coarsely toothed at the apex, lobes and teeth bristle-tipped; acorn ovoid, about twice the length of the cup, cup hemispheric or top-shaped, commonly short-stalked, scales more or less pubescent, the upper somewhat squarrose. *Quercus tinctoria* Bartram, Travels, 37, name only, 1791; *Quercus coccinea* var. *tinctoria* A. Gray, Man., Ed. 5, 454, 1867.

The Quercitron is infrequent in Iowa, and occurs in upland woods. The species is readily distinguished in the woods, but not so readily from the herbarium specimens. The color of the outer and inner bark is the safest guide. The pubescence in the axils of the veins beneath varies, and is to be found in *Quercus coccinea* Wang. The squarroseness of the scales intergrades.

The Quercitron has been confused with the scarlet oak to such a degree by Iowa botanists that it is extremely difficult to give any definite information regarding its range in Iowa. The reports of the species from eastern Iowa seem the more credible. We have looked upon the reports from western Iowa with considerable suspicion.

For many years the species has been recognized as occurring in Johnson county. Dr. White reported the species from Iowa, and was quoted by Professor Bessey. Professor Macbride reported the species from Dubuque and Humboldt counties; Messrs. Nagel and Haupt, from Scott county; Professor Pammel, from Hardin county; Professor Fink, from Fayette county; Mr. Gow, from Adair county; Mr. Rigg, from Calhoun county; and Messrs. Barnes, Reppert, and Miller, from Scott and Muscatine counties.

White, Geol. Sur. of Iowa, Vol. 1, p. 138; Bessey, Contr. to the Flora of Iowa, p. 119; Arthur, Contr. to the Flora of Iowa, p. 29; Nagel and Haupt, Proc. Davenport Acad. of Nat. Sciences, Vol. 1, p. 163; Fink, Proc. Iowa Acad. of Sciences, Vol. 4, p, 101; Gow, Proc. Iowa Acad. of Sciences, Vol. 6, p. 61; Cameron, Iowa Geol. Sur., Vol. 8, p. 198; Macbride, Iowa Geol. Sur., Vol. 7, p. 107; Vol. 9, p. 153; Vol. 10, p. 648; Pammel, Iowa Geol. Sur., Vol. 10, p. 313; Barnes, Reppert, and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 256; Rigg, Notes on the Flora of Calhoun county, p. 25.

Quercus ellipsoidalis E. J. Hill, Botanical Gazette, Vol. 27, p. 204, 1899. Tree twenty-five to sixty feet high, one to three feet in diameter, bark rather smooth, shallow-fissured, darkish colored near the ground, dull gray above, dull red within,

yellowish next the wood; leaves similar to *Quercus palustris* DuRoi; acorn solitary or in pairs, ellipsoidal, varying to somewhat cylindrical or globose, one-third to one-half immersed; cup turbinate or cup-shaped, thinnish, usually tapering into a peduncle; scales narrowly ovate, obtuse or truncate, brownish, pubescent, closely appressed.

This species is represented in Iowa by one tree growing near Big Rock, Scott county. Further search will probably find the species of frequent occurrence.

Hill, E. J., Bot. Gaz., Vol. 28, p. 215; Barnes, Reppert, and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 256.

††Leaves 3-5-lobed toward the apex.

Quercus marylandica Muench, Hausv., 5:253, 1770. Black-Jack or Barren Oak. Our representatives of this species are usually small trees; leaves obovate, stellate-pubescent above, rusty-downy beneath when young, 3–5-lobed toward the apex, lobes entire or bristle-toothed, base rounded or subcordate; acorn ovoid, twice the length of the cup, surmounted by a conical dome; cup deep; scales oblong-lanceolate, appressed, pubescent. *Quercus nigra B* L., Sp., Pl. 995, 1753.

So far as our observations go this species occurs only in dry soil on the uplands. It is infrequent or even rare, occurring in Decatur and Appanoose counties, where our specimens were obtained. The probabilities are that the species occurs in Iowa only on the southern border. The species occurs in Nebraska, ranges southward to Texas and eastward to Ohio and New York, but does not occur northward. Specimens from Decatur county were sent to the Missouri Botanical Gardens for final determination.

Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 6, p. 197.

Quercus nigra L., Sp., Pl. 995, 1753. Water Oak. With us this species is usually small; leaves spatulate, or sometimes entire and rounded, coriaceous, short-petioled, both sides green and glabrous, tufts of hair in the axils of the veins beneath; acorn globose, ovoid, with a slight but

broad dome, one-third or one-half immersed; cup saucer-shaped.

The character of the dome of the acorn readily distinguishes this species from *Quercus marylandica* Muench. Our specimens were obtained in one locality in Decatur county, which, so far as we know, is the only locality in the state. We published the species in Vol. 8, p. 314, Iowa Geological Survey as frequent. The publication was based upon genuine specimens, but at that time we had not learned to distinguish the species from *Quercus marylandica* Muench. We now believe that *Quercus nigra* L. is a rare species in Iowa. We have also published the species in Proceedings of the Iowa Academy of Sciences, Vol. 5, p. 164. All the trees we have observed occurred on dry uplands, and were associated with *Quercus marylandica* Muench.

Arthur, Contr. to the Flora of Iowa, p. 29; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 164; Iowa Geol. Sur., Vol. 8, p. 314.

††† Leaves entire.

Quercus imbricaria Mx., Hist. Chen. Am., 9, Pl. 15, 16, 1801. Laurel Oak. Shingle Oak. Leaves lanceolate or oblong, entire, bristle-tipped, acute at both ends, short-petioled, glabrous above, persistently downy beneath; acorn subglobose; cup hemispheric, shallow, scales ovate-lanceolate, appressed.

In Iowa this species is found only in the southern half of the state and in that portion it is common, forming much of the upland woods. Trees rarely exceed one or two feet in diameter. The wood is light reddish brown and coarse-grained. The wood is utilized for fuel, coal props, and to a very limited extent for local lumber. Our specimens are from Johnson, Washington, Decatur, Ringgold, and Clarke counties. We have observed the species in Jefferson, Wapello, Appanoose, and Union counties. The State University has specimens from Henry, Des Moines, Van Buren, and Taylor counties. Mr. Reppert reports the species from Muscatine county.

White, Geol. Sur. Iowa, Vol. 1, p. 138; Bessey, Contr. to the Flora of Iowa, p. 119; Arthur, Contr. to the Flora of Iowa, p. 29; Pammel, Proc. Iowa Acad. of Sciences, Vol. 1, pt. 2, 1890-1891, p. 91; Fitzpatrick, Proc. Iowa Acad. of Sciences, Vol. 5, p. 164; Vol. 6, p. 196; Iowa Geol. Sur., Vol. 8, p. 314; Reppert, Iowa Geol. Sur., Vol. 9, p. 387; Macbride, Iowa Geol. Sur., Vol. 7, p. 108; Gray's Manual, Ed. 6, p. 478; Barnes, Reppert, and Miller, Proc. Davenport Acad. of Nat. Sciences, Vol. 8, p. 257; Sargent, Forest Trees of N. A., p. 154.

SHRUBS AND TREES OF MADISON COUNTY.

H. A. MUELLER.

Madison county is considered a prairie country, yet fully one-fourth of its area is covered with shrubs and trees of some description. The county is traversed from the west to the east by three medium-sized streams, North River, Middle River, and Clanton Creek; thus it is known as the "Three-river country." North River, with its two larger tributaries, North Branch and Cedar Creek, is situated in the north half of the county. The principal timber areas along these streams are in Douglas, Jefferson, and Union townships. Middle River flows through the central part, while its largest tributary, Clanton Creek, flows through the south half from the southwest to the northeast. The larger bodies of timber along these two streams lie principally in Lincoln, Scott, Walnut, and South townships. Nearly three-fourths of South township has been covered with timber. South River flows through a small portion of the southeast part. There is not much timber growing on this stream. Grand River, west of the Mississippi-Missouri divide, flows through the southwest corner of the county. Some timber is found along this stream and its branches.

The surface of Madison county is quite rolling, notably so in the eastern portion. The streams flow through well-

developed valleys which have been cut down into the Des Moines stage of the Carboniferous. Nearly everywhere along the brow of the bluff are exposures of limestone of the Missourian stage. Sandstone of the Des Moines stage is found in the eastern part of the county. The hill slopes, and ridges lying near the larger streams are loess-covered; the prairies are covered with a dark, black loam.

On the hills and clay ridges grow the white and black oaks, the ironwood and the hickory. The basswood and the bur oak flourish on the lower slopes; the ash, the elms, the buckeye, the walnuts, and the hard maple on the bottoms. Along the river banks are found the box-elder and soft maple, the cottonwood and the willow. The hazel, the plum, the crab apple and the haw may be found everywhere.

In spite of the fact that the primeval forest is nearly exhausted, the timber area has increased to a considerable extent since the first advent of man in 1846.

After the prairies were broken out no more fires swept over the country, keeping the timber confined to a narrow strip along the streams. Thus within the last forty years there has developed what is known as "second-growth" timber, which is found growing on the outskirts of the original timber area.

At present not many large trees are left standing, and these are rapidly disappearing. Since the fencing is done almost entirely with wire, only fence posts are in demand. These posts are made principally from second-growth white and bur oak. Wood for fuel is still quite plentiful, yet it is diminishing at a rapid rate.

What will be the outcome of the forest conditions of Madison and other counties of Iowa? Will the hills and valleys be stripped of the clothing nature intended they should have, or will man awake to his folly and cease destroying the forests without replacing them? This is a question worthy of intelligent consideration. The problem of forests has been solved in some of the European countries, especially in Germany

Since good farming land has increased so much in value within the last five years the timber land will be encroached upon more and more for farming purposes. All the best timber land has been under the plow for some time. The portion that remains now consists mostly of the steep hill-slopes and clay ridges on either side of the streams.

One hopeful fact is that the small wood lots are being gathered together into larger areas and used for pasture, thus to a certain extent preserving the timber, yet pasturing is detrimental to young trees. Man and the goat are doing their part in destroying the young trees and underbrush of the steep hills.

Madison county has enough rough land, unfit for the plow, to grow sufficient timber to supply all her people with fuel and fence posts, if the proper care be given it. A good oak post can be grown in twenty years, and timber for fuel in less time.

Is it not true that the government should make some provisions to preserve the forest upon land that is of little use otherwise than grazing?

The following is a list of shrubs and trees found in Madison county:

Angiospermæ.
Dicotyledones.

TILIACEÆ.

Tilia americana Linn. Basswood. Linden.
Common on bottoms and lower slopes of hills between the oak ridges and the bottom land.

RUTACEÆ.

Xanthoxylom americanum Mill. Prickly Ash.
Common everywhere.

CELASTRACEÆ.

Celastrus scandens Linn. Climbing Bitter-Sweet.
Frequent, found everywhere climbing over shrubs.

Euonymus atropurpureus Jacq. Wahoo. Burning Bush.
This is quite common on the bottoms and along ravines.

RHAMNACEÆ.

Ceanothus americanus Linn. New Jersey Tea. Red-Root.
Quite common on the prairies and edge of the timber.

Rhamnus lanceolata Pursh. Buckthorn.
Common among cherry and plum thickets.

VITACEÆ.

Vitus riparia Michx.
The wild grape is very common along our streams and ravines. It may be found along every old fence or hedge row.

Ampelopsis quinquefolia Michx. Virginia Creeper.
Common. Dry woods and fences.

SAPINDACEÆ.

Æsculus glabia Willd. Ohio Buckeye.
Very common on the river bottoms.

Acer dasycarpum Ehrh. Soft Maple.
Very common along the river banks. This tree composes ninety per cent of our artificial groves.

Acer saccharinum. Sugar or Hard Maple. Rock Maple.
Common, found principally in groves on the river bottoms.

Negundo aceroides Moench. Box Elder. Ashleaved Maple.
Very common along the rivers and tributaries, growing in rich, alluvial soil.

ANACARDIACEÆ.

Rhus glabra Linn. Common Sumac. Smooth Sumac.
Very common everywhere.

Rhus toxicodendron Linn. Poison Ivy. Poison Oak.
Very common in timber and along fences and hedge rows.

LEGUMINOSÆ.

Gleditschia triacanthos Linn. Honey-Locust.
Not common.

Robinia pseud-acacia Linn. Black Locust.
Found only where planted, or escaped from cultivation.

Gymnocladus canadensis Lam. Kentucky Coffee Tree.
Frequent in rich soil of river bottoms.

LEGUMINOSÆ.

Amorpha canescens Nutt. Lead Plant.
Common on the prairies.

Amorpha fruticosa Linn. False Indigo.
Very common on wet, swampy ground on bottoms and along sloughs.

ROSACEÆ.

Prunus americana Marsh. Wild Plum.
Common everywhere on rich soils.

Prunus pennsylvanica L. f. Wild Red Cherry.
Rare.

Prunus virginiana Linn. Choke Cherry.
Common. Found in rich soils with the plum.

Prunus serotina Ehrh. Wild Cherry. Black Cherry.
Very common everywhere.

Physocarpus opulifolius Maxim. Ninebark.
Frequent along banks of streams and ravines.

Rubus villosus Ait. Blackberry.
Common on slopes of hills. Much killed by pasturing.

Rubus occidentalis Linn. Black Raspberry.
Not so common as the Blackberry, and found in the same localities.

Rosa blanda Aiton. Wild Rose.
Very common.

Rosa Arkansana Port.
Found on the prairies.

Pyrus coronaria Linn. American Crab-Apple.
Very common, growing in clumps in rich soil, along with the Plum.

Cratægus coccinea Linn. Red Haw. Hawthorn.
Not common.

Cratægus crus-galli Linn. Cockspur Thorn.
Rare.

Cratægus tomentoso Linn. Thorn Apple.
Very common. Found same localities with Plum and Crab-Apple.

Amelanchier canadensis T. & G. June-berry. Service-berry.
Common on steep hillsides along ravines.

SAXIFRAGACEÆ.

Ribes gracilis. Wild Gooseberry.

Common in rich soil in open ground and along fence rows and hedges.

CORNACEÆ.

Cornus sericea.

Common along streams and in wet places.

Cornus alternifolia L. f. Alternate-leaved Cornel.

Quite common on hillsides.

Cornus paniculata L'Her. Panicled Cornel.

Common everywhere in thickets.

CAPRIFOLIACEÆ.

Sambrucus Canadensis Linn. Elderberry.

Very common on low, rich bottoms Difficult to kill on cultivated lands.

Viburnum lentago. Black Haw.

Rare.

Symphoricarpos vulgaris Michx.

Very common along roadsides and open ground where the hazel has been cleared. This shrub has become quite a nuisance in timber pastures and along fences and hedge rows.

Lonicera glauca. Honeysuckle.

Frequent in woods on hillsides.

RUBIACEÆ.

Cephalanthus occidentalis Linn. Button-Bush.

Not frequent; found only in ponds and wet places.

OLEACEÆ.

Fraxinus americana Linn. White Ash.

Quite common on river bottoms and along streams.

URTICACEÆ.

Ulmus pulva Michx. Red Elm. Slippery Elm.

Common. Rich upland and bottoms.

Ulmus americana Linn.

Very common. Everywhere in damp woods.

URTICACEÆ.

Ulmus racemosa Thomas. Hickory Elm. Rock Elm.

Not common. There were several large groves in an early day on North River. A few trees are now found about the mouth of North Branch.

Celtis occidentalis Linn. Hackberry.

Common on river bottoms and along ravines.

Morus rubra Linn. Red Mulberry.

Not common. River bottoms.

PLATANACEÆ.

Platanus occidentalis Linn. Sycamore. Buttonwood.

Along streams near water's edge and old river channels on gravel beds. Union and Douglas townships.

JUGLANDACEÆ.

Juglans cinerea Linn. Butternut.

White Walnut. Common on rich river bottoms; trees have been cut two and one-half to three feet in diameter.

Juglans nigra Linn. Black Walnut.

This tree was very common in an early day on the rich bottoms, but the large trees have all been cut. They were sold and shipped East. In early days rails were split from the best logs. There are many groves of young trees.

Carya alba Nutt. Shellbark Hickory.

Common on the uplands.

Carya amara Nutt. Bitternut.

Common everywhere. Trees on the upland are dying from the effects of drouth and pasturing.

CUPULIFERÆ.

Corylus americana Walt. Hazelnut.

Very abundant on the outskirts of the timber, and where the trees are small and scattered.

Ostrya virginica Willd. American Hop-Hornbeam. Ironwood. Common along steep hillsides.

Quercus alba Linn. White Oak.

Common on clay ridges.

Quercus Muhlenbergii. Chestnut Oak.
Not common. Found on steep, rocky hillsides.
Quercus macrocarpa Michx. Bur Oak.
Very common. Found everywhere, but more abundant on the upland.
Quercus palustris Du Roi. Spanish Oak.
Frequent.
Quercus rubra Linn. Red Oak.
Common.
Quercus coccinea Wang. Scarlet Oak.
Quite common on upland.
Quercus coccinea Var. *tinctoria* Gray. Black Oak. Jack Oak. Common on upland.

SALICACEÆ.

Salix tristis. Dwarf Willow. Gray Willow.
Somewhat rare. Found on upland bordering thickets.
Salix humilis Marsh. Prairie Willow.
Common on uplands.
Salix discolor Muhl. Pussy Willow.
Rare; wet places.
Salix longifolia Muhl. Sand-bar Willow.
Common in low, wet places and on sandbars.
Salix nigra Marsh. Black Willow.
Very common along the banks of streams.
Populus tremuloides Michx. American Aspen. Quaking Asp. Rare. Upland.
Populus monilifera Ait. Cottonwood.
Very common along streams, the largest trees growing on very low ground near the water. This tree makes very rapid growth. Trees become large enough for lumber in thirty to forty years.

Monocotyledones.

LILIACEÆ.

Smilax hispida Muhl. Greenbrier.
Quite common in rich woods.

GYMNOSPERMÆ.

CONIFERÆ.

Juniperus virginiana Linn. Red Cedar.

Rare. Found on steep bluffs along North River and Cedar Creek. In Douglas Township there was a small grove on a rocky bluff, wherein the trees reached a foot or more in diameter.

A TERRACE FORMATION IN THE TURKEY RIVER VALLEY, IN FAYETTE COUNTY, IOWA.

BY G. E. FINCH.

The Turkey River flows, in the lower part of its course, through the driftless area in Fayette county, through wide bottom lands. These are usually a half-mile, sometimes a mile or more in width, showing considerable progress in base-leveling.

Fringing the bluffs on one or both sides of the river may usually be found a "bench," rising ten or twenty feet above the general level of the valley. A few rods northwest of the Huntsinger bridge over the Turkey River in Dover township, Fayette county, a small tributary called Dry Run, coming from the north, has cut into the side of one of these terraces from top to bottom, showing in a broad, concave curve, a section about 300 feet long and 25 feet high. Several formations are exposed. Starting at bed rock and extending upward about three feet, is an iron-stained formation that seems to be residual. It is composed largely of cherty fragments from the lower part of the Maquoketa shales with a smaller mixture of greenstones and quartz pebbles, all imbedded in rusty earth. Above this occurs some eight feet of a loess-like material, merging into a soil at the top. Somewhat abruptly above this, the bank changes to thin-bedded sand and gravel strata for about four feet. Then occurs six feet of limestone fragments with a small percentage of glacial pebbles, packed so close and even in horizontal layers as to

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Terrace near Huntsinger Bridge, Dover Township, Fayette County, Iowa.
Soil merging into a layer of limestone fragments and interbedded loess masses followed by banded sand and gravel which rests upon loess topped by soil.

suggest stratified rock in places. This formation gradually merges into two or three feet of loess soil at the top of the section. In places in the formation composed of limestone fragments, are inclusions of loess in detached, irregular blocks. Most of these are small, but one was observed that was estimated as twelve feet long and two and one-half feet thick. All the loess masses are irregular and sharply separated from the surrounding rock fragments.

The terrace can be traced for over half a mile; first, a short distance east and west in the river valley, then bending sharply to the north and fringing the valley of Dry Run on the west. At the end of the terrace next the river an exposure shows the limestone fragments of the formation underlying the subsoil, to be often as large as a foot across; while at the exposure before described, which is some distance up Dry Run from the river, they are not more than two or three inches in width.

Back of the terrace is a loess-covered hill of moderate slope, estimated at 75 feet in height. Across the river, fully half a mile away, is a terrace opposite the one described, and seeming to be at the same level.

The presence of the loess and soil in the lower half of the section described is evidence that antecedent to the formation of the terrace, the ground subsequently covered by it was dry land above the reach of the river. Afterwards a stream as large as the Mississippi at Lansing, Iowa, flowed through the valley, filling it from bluff to bluff. It drowned the mouths of tributary streams and backed up their valleys for a considerable distance. Thus the layers of sand and gravel were laid; then occurred the deposit of the lime-rock fragments, largest in the strong waters of the main stream and growing smaller where the waters were embayed. Lastly came the rapid recession of the swollen waters.

That the deposition of the terrace was at a rapid rate is shown by the burial of the loess fragments in the loose rock without any erosion or disintegration. It would seem probable that they were deposited while frozen; otherwise they would surely have been worn away. The flat

top of the terrace, several rods in width, renders it impossible that such fragments dropped off from some overhanging bank. If we assume that the terrace was deposited by the river while at its present size and that it has since cut down its valley leaving the terrace above it, we are at a loss to account for the soil-covered loess immediately under the terrace deposits. It seems evident, therefore, that the terrace in question was formed by a very brief and great rise in the waters of the Turkey river.

PURE FOOD LAWS.

C. O. BATES.

The demand for cheap goods and the intense strain produced by commercial competition has induced many dealers and manufacturers to adulterate their products. This practice enables them to satisfy the buyer and outwit their competitors, not to speak of the immediate financial advantage.

Many and wonderful have been the schemes to cheapen and multiply food and drug products. Some of them have been along the lines of honest scientific investigation and discovery. And their triumphs remain as perpetual monuments to such thought and enterprise. It is not to this side of the subject that we wish to give attention in this paper, but to the other side of the subject, viz.: the schemes for cheapening and multiplying food products by fraud and deception.

There is no law until there is an infringement of rights. Pure food laws, like the common laws of England, are the outgrowth of the just and righteous demand of an honest, prosperous and progressive people. It is not a "King John" that they have to contend with, but a more subtile, selfish and powerful "King Mammon." While the question of Pure Food Laws is in its incipient stage in this country, it should receive the hearty support of every thoughtful

person. Such laws are based on sound principles, and when properly brought to light, will be sustained by an intelligent public sentiment.

It was the dream of Napoleon to obtain food direct from the elements and their ordinary compounds without the aid and intervention of life force, but he did not resort to mixing ground cigar boxes with cinnamon, or pulverized cocoanut shells with pepper in order that each soldier of his army might receive his full weight of rations.

A greater army than Napoleon's striving for greater conquests exists on the American continent to-day, viz.: The American people, striving not only to establish good government and individual protection, but also to extend this good government and individual protection to the very food we eat and drink. In order to do this it is necessary that the government call to its aid all the light that science is able to give; and as chemistry is the most fundamental and exact of the sciences, to begin with, the work will be largely one of chemical investigation.

Among the many subjects that may come before the Academy of Sciences of the State of Iowa, none would be of more interest or of greater value to the public than the investigation *first*, of food products, and *second*, their effects on the human system.

The wholesale adulteration of food products, is a great evil, injurious alike to the reputable dealer and to the public. A drug is adulterated when it differs in strength, quality of purity, from that laid down in the Pharmacopeia.

A food is adulterated: *First*, if any substance has been mixed with it so as to lower or depreciate or injuriously affect its quality or purity; *second*, if any inferior substance has been wholly or in part substituted for it; *third*, if any valuable or necessary ingredients have been abstracted from it; *fourth*, if it is an imitation, or sold under the name of another article; *fifth*, if it consists wholly or in part of deceased or decomposed animal or vegetable substance; *sixth*, if it is colored, coated, polished or powdered, whereby damage or inferiority is concealed, or if by any means it is made to appear better or of greater value than

it is; *seventh,* if it contains any added substance or ingredients which are poisonous, or injurious, or deleterious to health, or if it contains any deleterious substance not a necessary ingredient in its manufacture.

Candies are adulterated with chalk, or baryta, to give them weight; adulterated with flour to give them bulk; and adulterated with analine to give them color, and adulterated with saccharine to give them sweetness.

Strained honey is adulterated by dropping into a half-pound glass jar of glucose, a small piece of highly flavored honey in the comb, with an occasional fragment of the body of the bee. In some instances this might with propriety be called the adulteratiion of glucose instead of the adulteration of honey.

Syrups are adulterated with glucose and colored with analine colors, soured syrups are neutralized and reboiled, thereby producing compounds that are very deleterious to health.

Flavoring extracts, such as lemon and vanilla, are as a usual thing adulterated, containing an exceedingly small amount of the essential reagent, and are colored with coal tar products or caram'l. In some instances there is absolutely none of the essential reagents in the so-called extracts.

And so on we might mention almost the entire list of the grocer's goods and many of the druggist's stock of goods.

Second. As to the effects on the human system, foods may be divided into three classes: *First,* those that are wholesome; *second,* those that are questionable; *third,* those that are harmful.

The unsuspecting public has a right to be protected from harmful and questionable foods; the public also a right to be protected in the case of adulterations, whether or not they are injurious to health.

Greed for gold in America is doing what malice in barbarous and semi-barbarous countries is doing, viz.: putting poison even in the foods we drink. The law lends a helping hand in the case of burglary and piracy, but is

slow to declare against the man who robs your food of its nutritious qualities. The man who steals your purse is punished by the law; the man who steals your health is protected by the law; the man who counterfeits your money is imprisoned; the man who counterfeits your food is not molested in his nefarious practice. As Congressman Cousins has said: "It is about time in this country when it should not be necessary to hold a coroner's inquest or have a chemical analysis before asking a blessing."

All the state food laws that have thus far been enacted are of a similar character, and are based on the laws of Massachusetts or upon the laws of Ohio, which are the same as those of Massachusetts made more specific. The National food law proposed and known as the "Brosius Bill," affects only interstate commerce and the territories of the United States. It is similar to the laws of Massachusetts, but has been greatly weakened by the insertions that manufacturers have smuggled in.

As far as I can ascertain the pure food laws are well in force in some of the states, while in others, aside from the dairy laws, they are a dead-letter.

In New York, and Massachusetts, and Indiana, the enforcement of the food laws has been delegated to the the State Board of Health, and not to special commissioners whose sole duty is to see that the laws are enforced, and if necessary, prosecute the offenders. The result has been that the State Board of Health in each instance has been exceedingly lax.

In Connecticut the Food Commissioner has charge of the enforcement of the laws, the analytical work being done at the State Agricultural Experiment Station, and the result has been that the laws have been well enforced.

In Michigan, Ohio, and Wisconsin, the laws have been quite well enforced by a somewhat similar arrangement, but in each instance the battle is fought along one or both of two lines, viz.: *First*, the definition and application of the words "mixture" or "compounds"; *second*, proving guilty knowledge on the part of the vendor.

In regard to the first, the law usually permits the sale of mixtures or compounds, provided they are labeled "mixture" or "compound," but the end of the law is defeated in some instances. For example, such goods as compound pancake flour, compound syrups, etc., are perfectly legitimate articles of food. But when it comes to compounding spices, it is evidently a different matter. The consumer may know, in a sense, what he is getting, but a label that confesses the crime, is evading the law in a bold manner.

In regard to guilty knowledge on the part of the vendor of adulterated foods it is difficult to convict. It will be claimed in his behalf that intent is the essence of crime. But if a saloon-keeper unintentionally sells to a minor, still he offends, and may be prosecuted successfully for his offense.

It will work no hardship in the long run to hold the grocer responsible for the purity of his goods. It is successfully done both in Michigan and Wisconsin. The grocer takes pains to buy his goods from a reliable house under written guarantee, then if he is prosecuted he can fall back on the wholesaler, likewise the wholesaler can fall back on the manufacturer.

NOTES ON THE EARLY DEVELOPMENT OF ASTRAGALUS CARYOCARPUS.

F. W. FAUROT.

While a student at the University of Nebraska the writer became interested in plant embryology, a subject which has attracted much attention during the past few years, especially since the remarkable work of Strasburger[1], Guignard[2], and other European botanists. Many American botanists, however, have since done much work along embryological and cytological lines, viz.: Chamberlain, Webber, Schaffner, Harper, Coulter, and others. Most of the work that has been done is of a purely technical and botanical character, excepting that done in the

PLATE IX.

Fig. 1. Young flower in which the pistil is not completely formed.

Fig. 2 Very young pistil showing budding of nucellus, *n*

Fig. 3. Young ovule with an archisporial cell (*a*), and showing origin of the integuments (*b*), dermatogen of nucellus *d*.

Figs. 4-5. There are two archisporial cells, *a*.

Fig. 6. Four archisporial cells, *a*; shows also decreased amount of nucellar tissue, *nt*, and integuments, *b*.

PLATE X.

Fig. 7. The lower archisporium (*a*) developing into macrospore at the expense of the other three cells, a_1.

Fig. 8. The macrospore (*a*) has attained nearly its full size, and only rudiments of the other three cells are present, a_1.

Fig. 9. A two-celled embryo sac, *a*.

Fig. 10. A four-celled embryo sac (*a*), the tip of which is now in close relationship to dermatogen, *d*.

Fig 11. An eight celled embryospsac (*a*), but only two cells of egg apparatus (*e*) are shown. Three antipodal cells (*at*), polar nuclei which have not yet united, *pn*.

Fig. 12. The same as 11, but a little later stage, polar nuclei *pn*. in process of fusion.

Fig. 13. Mature embryo sac ready for fertilization. Egg apparatus *e*, definutive nucleus *dn*, antipodals *at*.

Fig. 14. Egg cell undergoing process of fertilization. Egg nucleus *en*, pollen nucleus *pn*, pollen tube *pt*.

Fig. 15. Fertilized egg *e*; endorsperm nucleus *end*.

Fig. 16. Egg cell *e*, endosperm, *end*.

PLATE XI.

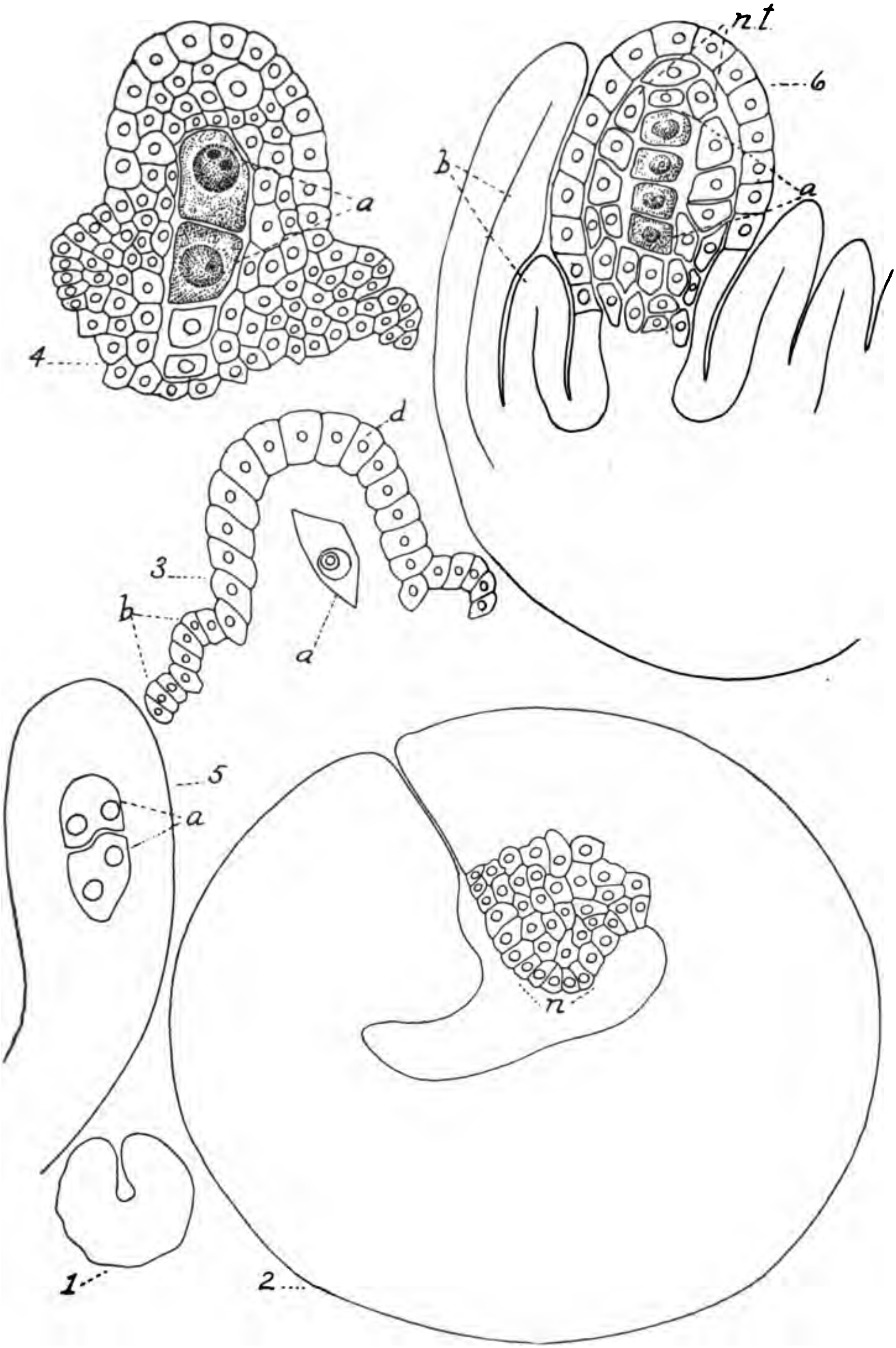
Fig. 17. Suspensor *s*, embryo *em*, endosperm, *end*.

Fig. 17½. Suspensor *s*, embryo *em*.

Fig. 18. Same os 17½, slightly older.

Fig. 19. Embryo and endosperm *a*, embryo enlarged. *b*.

Fig. 20. Nucellus, *auc;* integments, *it*, Micropyle, *m;* Embryosac, *em;* funiculus, *f*.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2

U. S. Department of Agriculture, where it has been carried on especially with reference to fertilization and its results[3]. Botanists have usually selected such material as could be most easily worked up, *e. g.*, such plants as many of the Ranunculaceæ and Liliaceæ, plants which have large pistils and large cells, and are easily oriented in paraffine. The Leguminous plants have not been so generally worked with, because they are ordinarily more difficult to handle.

The material used in the preparation of this paper was in all cases collected in close proximity to the laboratory and carried there before killing. Various killing mixtures were employed, viz.: Aqueous solution of corrosive sublimate: Distilled water, 100 parts, by weight. Sodium chloride, 6 parts. Acetic acid, 6 parts. Mercuric chloride, 8 parts. One-third per cent. aqueous solution of platinic chloride. Flemming's weaker solution:

Chromic acid, one per cent , 25 vols.
Osmic acid, one per cent., 10 vols.
Acetic acid, one per cent., 10 vols.
Distilled water, 55 vols.

Hermann's solution:

Platinic chloride, one per cent., 15 vols.
Glacial acetic acid, two per cent., 15 vols.
Osmic acid, two per cent., 2 vols.

After killing, the material was hardened in alcohol and stored in 80 per cent. alcohol. It was imbedded in paraffine and sectioned, 6–10 u, generally 6 u.

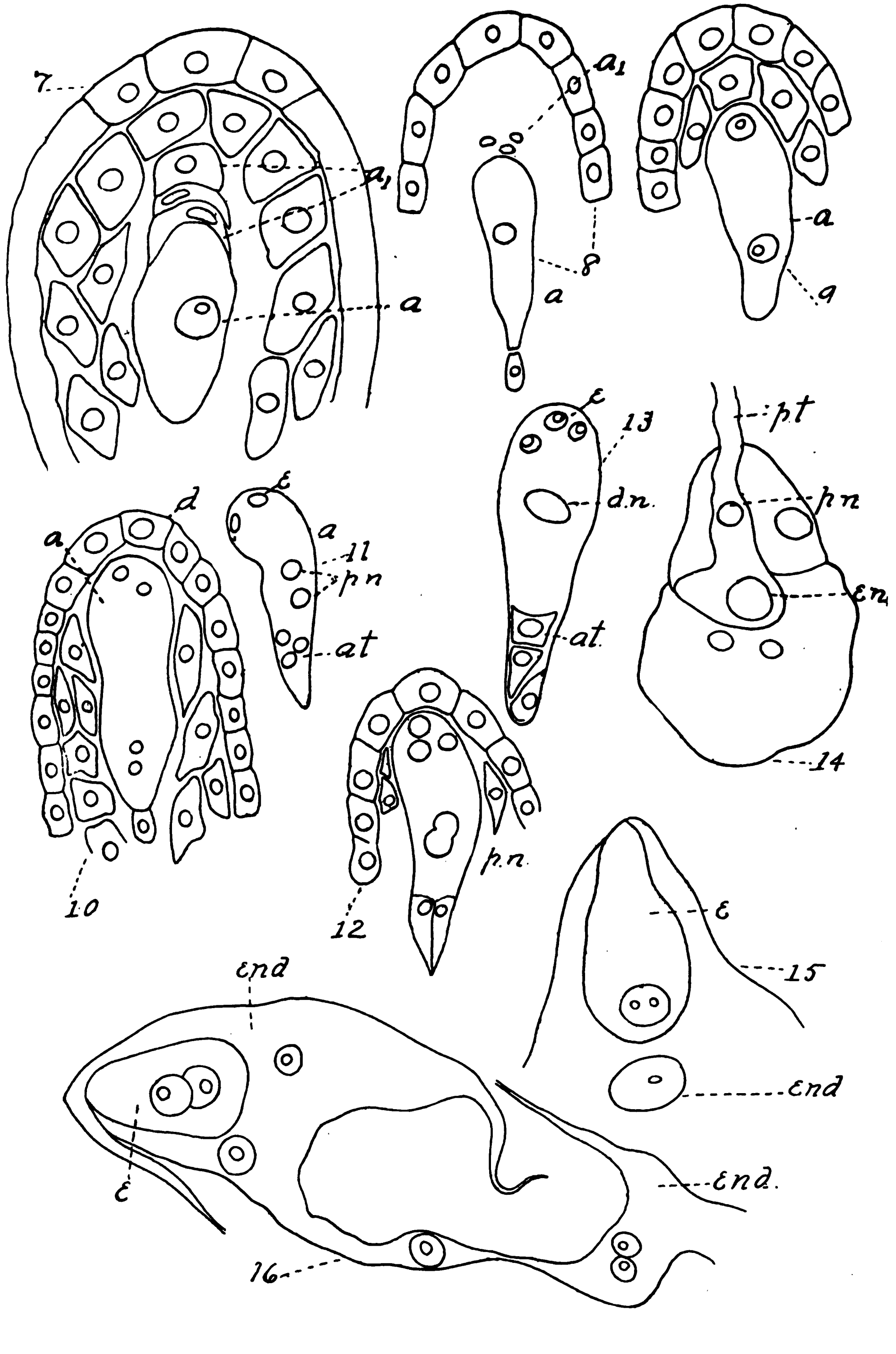
The best results were obtained from material killed in Flemming's. Good results were also obtained after platinic chloride. Hermann's, although one of the best killing reagents did not yield good results because the material was not decolorized, thus rendering staining very difficult. In imbedding, much difficulty was experienced in orienting the specimens. In very young pistils no trouble of this kind is met, but as they become older and the ovules are developing rapidly, they crowd each other out of position and drop in the cavity of the pistil, and the way they

droop probably depends on the way the flower hangs. This trouble begins about the time of formation of macrospores, and especially about the time of fertilization. In staining no attempt was made to obtain nuclear results in the way of karyokinetic figures, because of the extreme smallness of the cells. Only the most common stains were used, either Delafield's hæmatoxylon or a combination stain of eosin and hæmatoxylon. In all, about 500 flowers were sectioned, but only a few of this number were of any value, because so many were cut obliquely.

As soon as the leaf which forms the pistil has folded together, there is a proliferation of cells on either side of the suture formed by the fusion of the two edges of the leaf. As a result of the increased number of cells in this region, the nucellus is produced (Fig. 2) and soon becomes a prominent protrusion into the cavity of the pistil.

In the apical region of the nucellus one of the hypodermal cells undergoes marked differentiation. It increases greatly in size, becomes granular, and has a large nucleus. At about the time of the formation of the archisporial cell, the integuments are first making their appearance, the inner one appearing slightly before the outer one (Fig. 3).

The archisporial cell divides into two, and each of the resulting cells divides again, instead of two or three cells being cut off the tapetal end of the first cell formed, as is frequently the case. The presence of two nuclei in each archisporium (Fig. 5) in the two-celled stage, and the position of the cells in the four-celled stage (Fig. 6) indicates that each of the first two cells formed divides again. It is the lower cell of the row of four which develops into a macrospore at the expense of the other three (Fig. 7). After the first division of the nucleus of the embryo sac, and about the time or just before the fusion of the two nuclei which form the definetive nucleus, cell walls are formed around the antipodal cells (Fig. 12). The form of the antipodals is generally triangular. Concerning the position of the egg apparatus, it may be at one side of both synergids or below them Figs. 12, 13). The mature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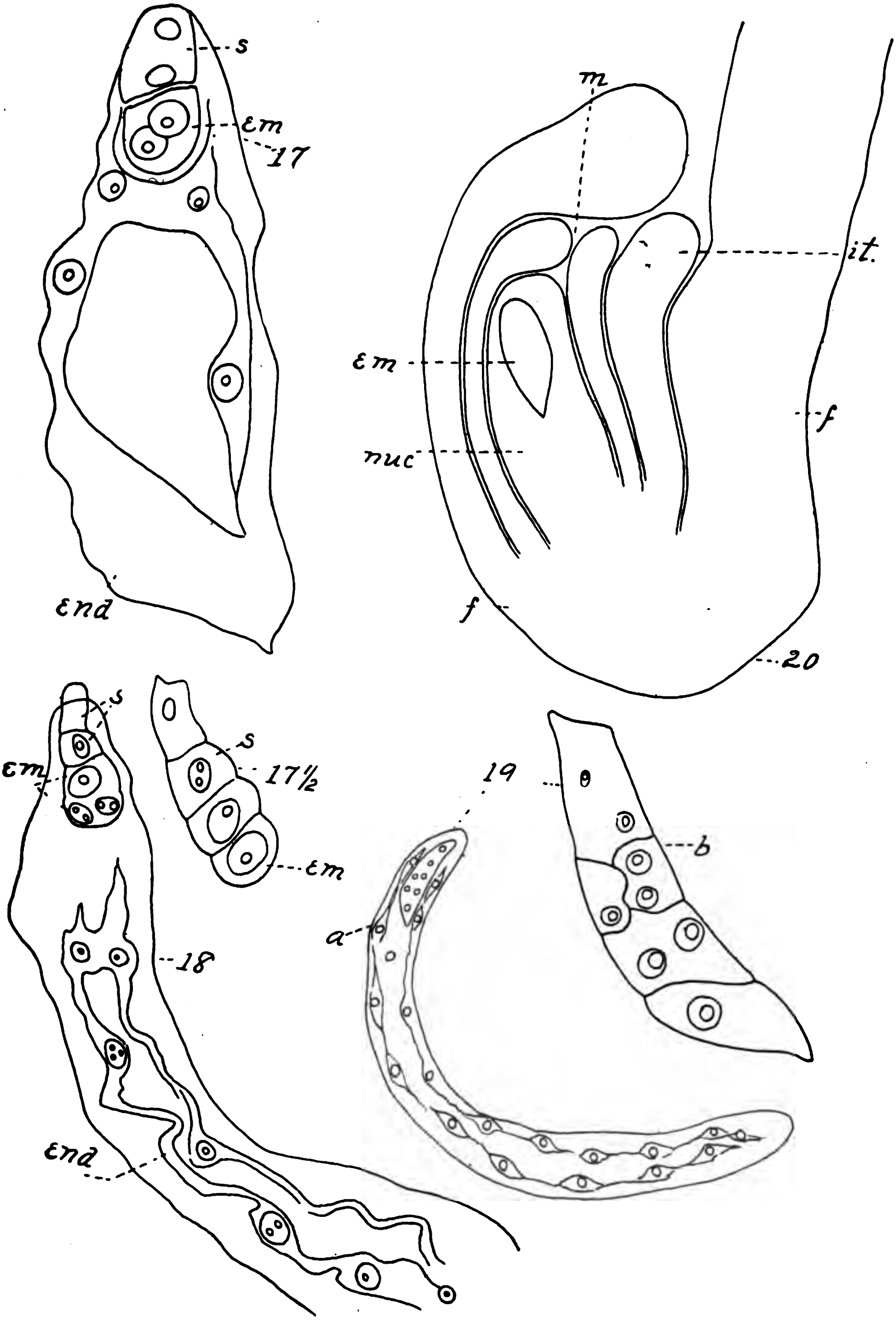
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embryo sac, ready for fertilization, measures approximately 52 u in length and 22 u in width, and occupies much less than one-third of the length of the nucellus in the one to the four-celled archisporial stage. There are generally about two layers of cells of nucellar tissue between the archisporium and the dermatogen of the nucellus (Fig. 3–6). From the four-celled archisporium to the two-celled embryo sac there is generally one layer of cells between the macrospore and the dermatogen, and by the time the embryo sac has reached the four-celled stage, the tapetal end of it is in close connection with the dermatogen, there being no tissue between the two.

At about the time the pollen tube enters the egg cell one of the synergids disappears. The other one remains apparently unchanged until the process of fertilization is completed, after which it is no longer present. The fusion of the generative pollen nucleus with the egg cell and the fusion vegetative nucles with the endosperm nucleus seem to occur at about the same time. The fertilized egg cell, before any division takes place, measures about 33 u long by 14½ u wide. The endesperm nucleus divides once before the first division of the egg nucleus takes place; the first division of the endosperm being in the direction of the long axis of the embryo sac. The second division is at right angles to the first, and it occurs at or just before the time that the egg nucleus divides the first time. The third division occurs in the lower two cells, resulting from the second division, and also occurs in the same direction as the second (Figs. 15, 16). The upper cells resulting from the first division do not divide until two or three divisions have taken place in the lower cells. But by the time the embryo has reached the four-celled stage the endosperm has extended well up along the side of the embryo (Fig. 17).

The first division of the egg cell is at right angles to the long axis of the cell, and it is the lower one of these cells that gives rise to the embryo. The upper one forms the suspensor. The embryo cell now divides once transversely. *i. e.*, in same direction of first division of egg cell.

The lower one of the two embryo cells now divides longitudinally. Just how further divisions of the embryo occur, it has not been possible yet to determine, because the sections were cut in an oblique plain.

The oldest embryo sectioned is shown in Fig. 19.

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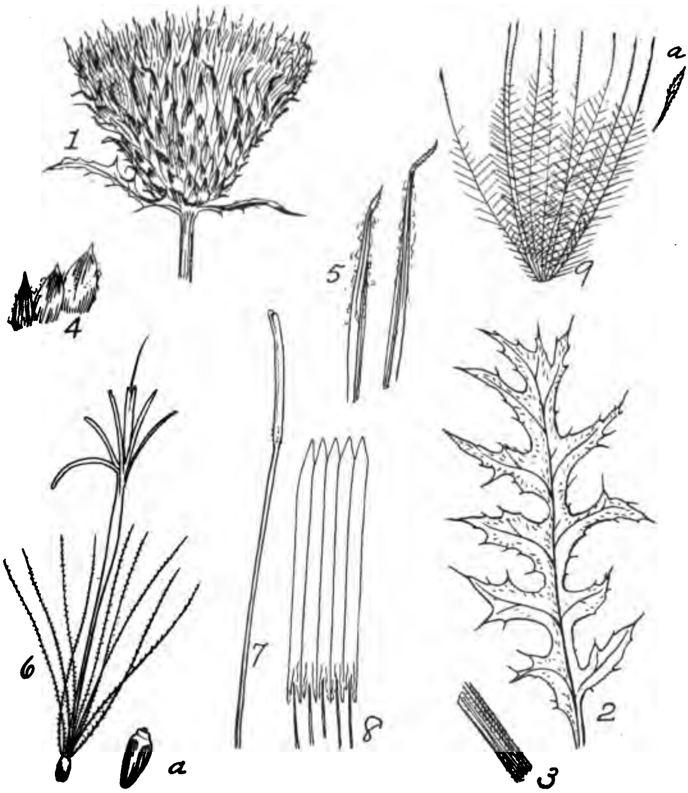
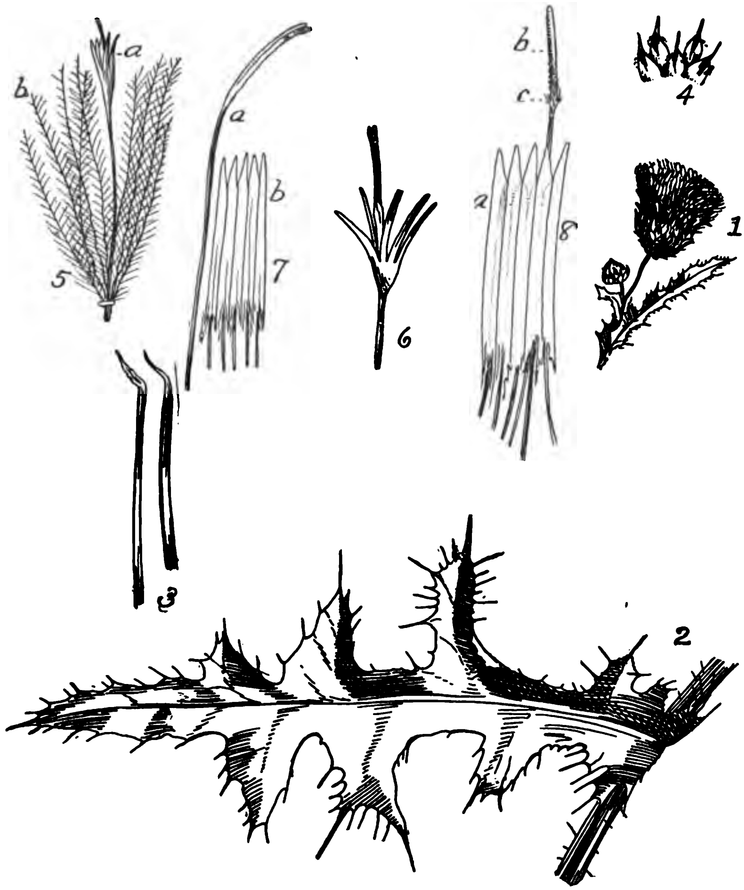
THE THISTLES OF IOWA, WITH NOTES ON A FEW OTHER SPECIES.

BY L. H. PAMMEL.

I have for some years been interested in a study of our thistles. During my study in St. Louis I had occasion to examine the rich collections of the Gray Herbarium, Harvard University, as well as that of the Engelmann Herbarium and the Missouri Botanical Garden, besides a considerable collection in the Parry and I. S. C. Herbaria. I should not attempt the publication of only a partial paper



Cnicus muticus. *1*. head; *2*. leaf; *3*. portion of stem; *4*. outer bracts; *5*. inner bracts; *6*. flower from outer row, pappus barbellate; *a*, achene; *7*, style; *8*, anthers; *9*, pappus of inner flowers. (Charlotte M. King.)



Cnicus arvensis. *1*, head; 2, leaf; *3*, inner bracts; *4*. outer bracts; *5*, flower. *6*, flower, with pistil and stamens; *7*, anthers and style; *8*, pistillate flower with style. (Charlotte M. King.)

on thistles, but it may be some time before I shall be able to get together the manuscript lost in the fire. With this apology I present these notes. I am especially indebted to Dr. William Trelease and Dr. B. L. Robinson for kindly allowing me to examine the material in their collections. Prof. T. H. Macbride and Prof. B. Shimek have also kindly permitted me to examine the material in the State University of Iowa. I am also indebted to Messrs. Reppert, H. W. Norris, T. J. Fitzpatrick, and Cratty, for the privilege of examining their collections. The collections of the State University and Mr. Reppert are quite full of Iowa material, and contain a number of interesting forms. I am also indebted to Professor Selby and Professor Hitchcock, for material from their respective states, and Mr. Miller, who was kind enough to look up some matters for me with reference to thistles in the vicinity of Davenport.

I have followed Dr. Gray in his interpretation of the genus, believing that the most logical one.

ECOLOGICAL.

Most of the thistles belong to that class of plants commonly called mesophytes, living in a climate and growing in a soil supplied with sufficient moisture to produce good agricultural crops. Thus it is that these plants are so commonly found on our prairies and in woods. A few of the western species are xerophytic, being adapted to a dry climate and a soil containing comparatively little moisture. A few are semi-hydrophytic, growing in soil that is quite moist, too moist for ordinary mesophytes. The *Cnicus muticus* is the only representative of this society in Iowa. The species are usually biennial, like the *Cnicus lanceolatus*, the seed germinating in the spring and producing a rosette of leaves. The rosette arrangement protects the plant from cold in the winter and mechanical injuries. The second season the plant sends up an erect stem that bears the foliage, and during late summer, flowers. Some,

Fig. 9. Leaves of the thistle (*Cnicus odoratus*).

like *Cnicus arvensis*, are perennial, and propagate by underground rhizomes, this being the chief mode of propagation for the Canada thistles in the west.*

* Although this species seeds abundantly in the east, seed is seldom produced in the west. Though many hundreds of plants have been examined by the writer west of Lake Michigan, in but a few instances have seed been found. A few were once found near Lincoln Park, and in abundance near Milwaukee, and once in northeastern Iowa. Experiments made as to their germination proved that the seed found in Milwaukee germinated freely.

† Ludwig. Lehrbuch der Biologie der Pflanzen 489.
Anton Kerner von Marilaun. Pflanzenleben, 2.
C. M. Weed. Ten New England Blossoms and Their Insect Visitors. 126.
L. H. Pammel. Flower Ecology. 71.
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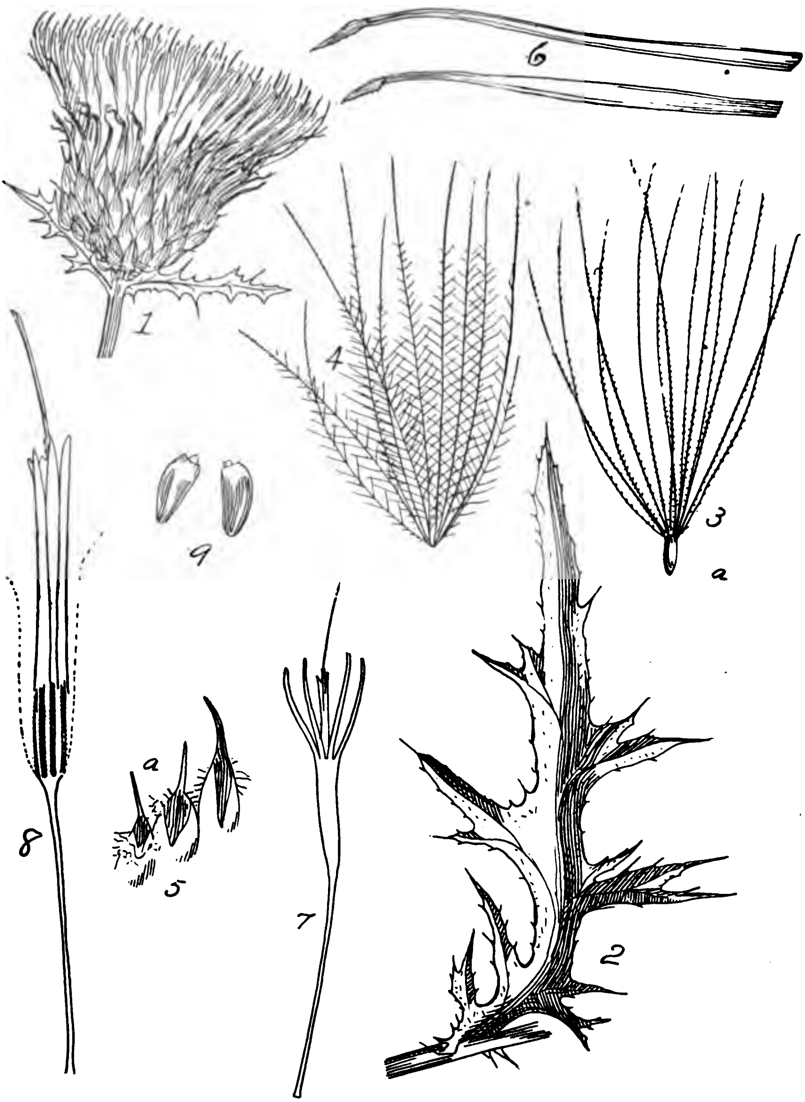
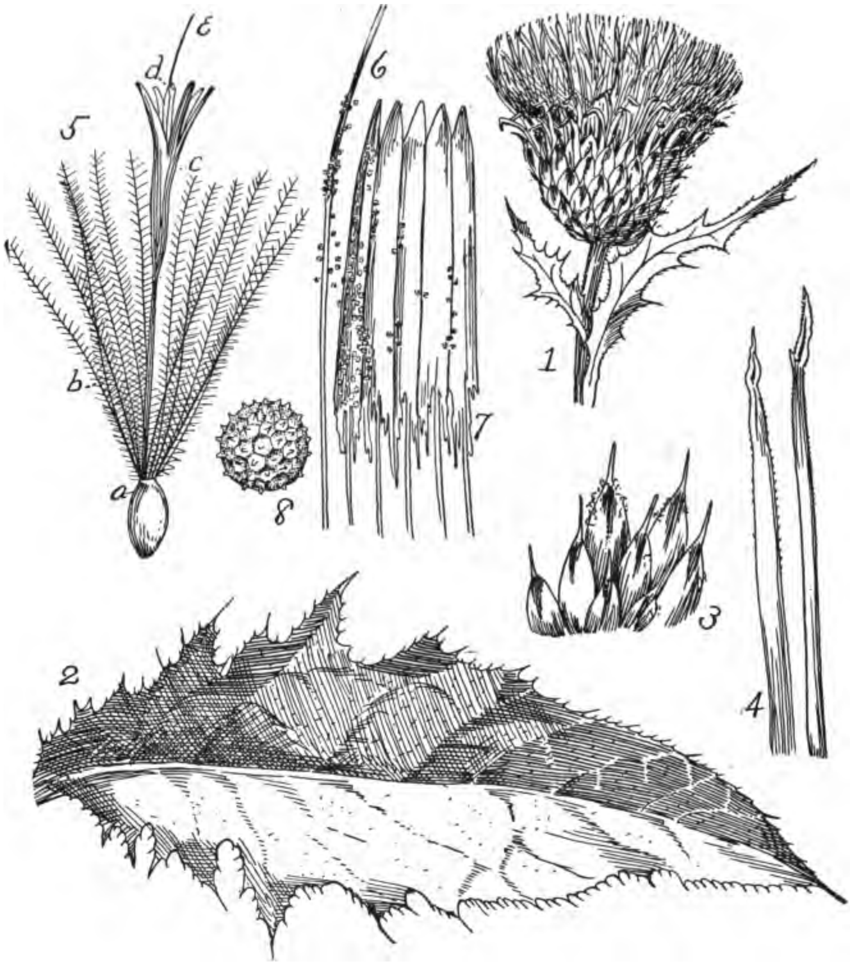


Cnicus discolor. *1*, head; *2*, leaf; *3-4*, pappus; 3, of outer row of flowers; 4, inner row of flowers; *5*, outer bracts; *6*, inner bracts; *8*, flower showing anthers, filaments and style. (Charlotte M. King.)



Cnicus altissimus, *1*, head; *2*, leaf; *3*. outer bracts; *4*, inner bracts; *5*, flower; *c*, corolla; *b*, pappus; *d*, anthers; *e*, style; *a*, achene; *6*, style and pollen; *7*, anthers; *8*, pollen grain. (Charlotte M. King.)

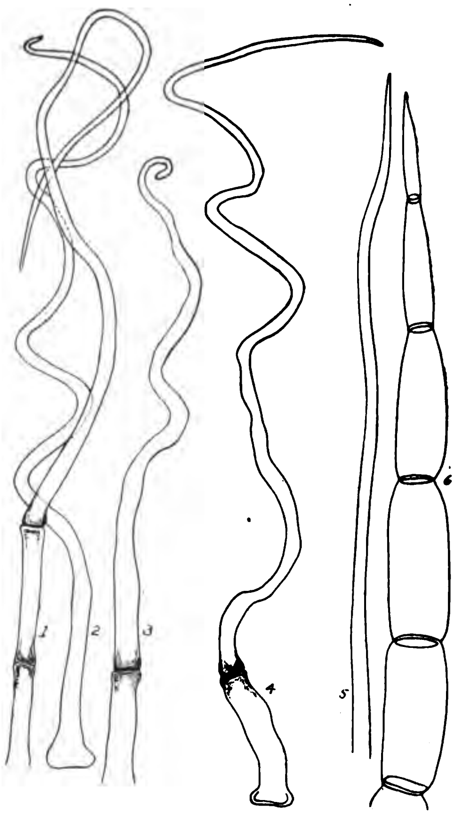


Fig. 10. Trichomes of thistle leaves and bracts.
1, from bracts of *C. muticus*; 2, leaves of *C. discolor*; 3, leaves of *C. Iowensis*; 4, bracts of *C. canescens*; 5, leaves of *C. lanceolatus*.

PROTECTION.—The thistles are admirably protected from herbivorous animals by their spiny leaves and bracts. This is true in a marked degree by such species as *C. arvensis* and *C. lanceolatus*, in a less degree by *C. altissimus* and *C. muticus*.

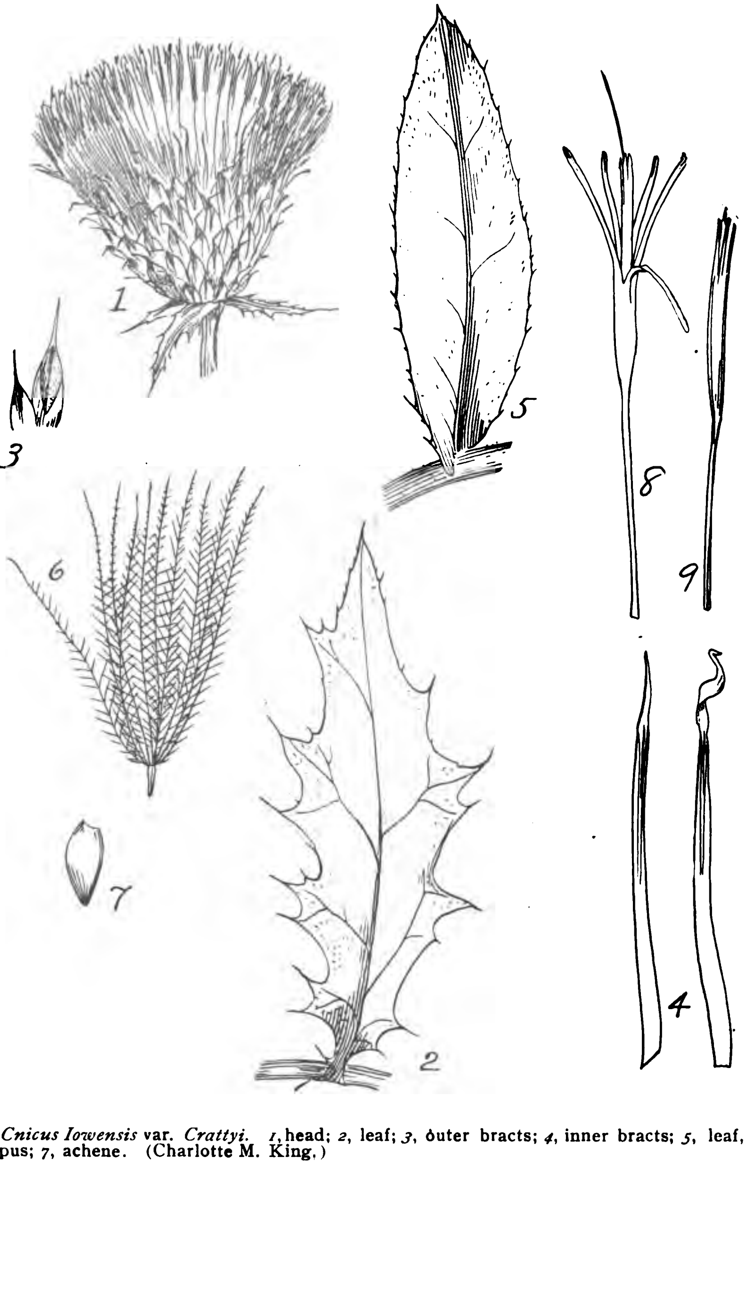
The involucral bracts are spiny, as in *C. lanceolatus*, somewhat spiny in *C. altissimus* and *C. arvensis*, with a broad glutinous ridge in *C. Iowensis*, *C. discolor* and *C. Hillii*. The spiny bracts serve to protect the plant from herbivorous animals and some crawling insects. This glutinous ridge not only prevents crawling insects from going into the head, but many small flying insects, especially

Fig. 11. **Leaf and bracts of *Cnicus Iowensis***
3, outer bracts showing the dorsal glutinous ridge and stout spines; 4, the inner long bracts.

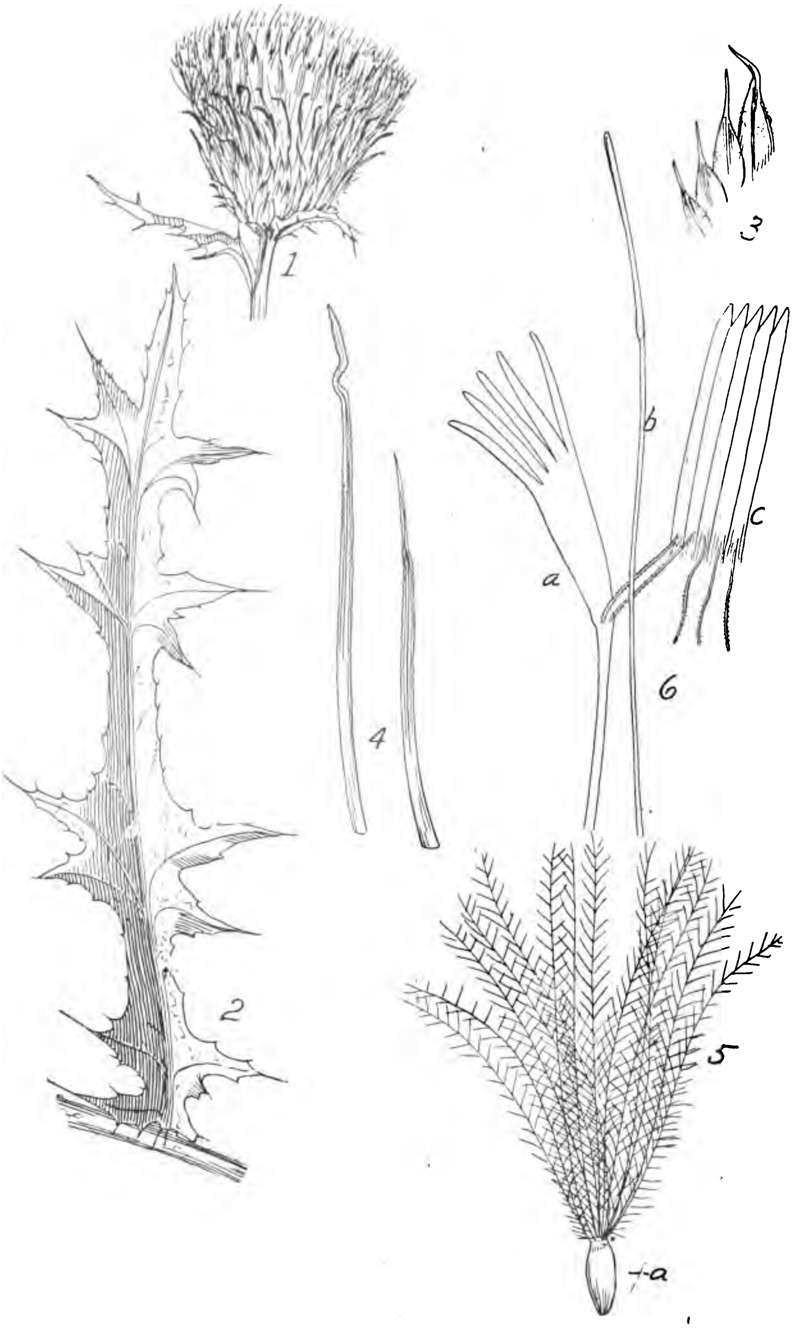
Diptera are held fast. The writer has observed ants and several different kinds of *Diptera* on these glands.

Pollination.—Several of the species have been studied in detail. Below will be found some of the references.†

All of the thistles bear conspicuous heads. The heads are many flowered and very attractive. Each flower consists of a long tubular corolla with a spreading limb. The tube is very much contracted. The anthers are united into a tube, the lower portion being usually sagitiate. The pollen grains of all the species are very spiny, and owing to this fact they adhere readily to the insect's body. The filaments are frequently hairy, or in some cases somewhat pilose. The flowers are strongly proterandrous. In the first stage a large quantity of pollen is pushed out by the style through the opening of the anthers. This is accomplished by the small brush hairs which occur at the joint on the style. In some few cases, however, these hairs are very much reduced. These hairs not only help to push the pollen out, but it prevents it from falling to the bottom of the corolla tube. The stamens, especially in *C. Iowensis* and *C. altissimus* and *C. discolar* are sensitive. By placing a brush or a lead pencil on the anthers they



Cnicus Iowensis var. *Crattyi*. *1*, head; *2*, leaf; *3*, outer bracts; *4*, inner bracts; *5*, leaf, *6*; pappus; *7*, achene. (Charlotte M. King.)



Cnicus undulatus. *1*, head; *2*, leaf; *3*, outer bracts; *4*, inner bracts; *5*, achene and pappus; *6*, flower with stamens; *c*, style; *b*, corolla. (Charlotte M. King.)

will be seen to move from one side and back in an irregular manner. A contraction of the filaments takes place; and it is this contraction that causes the pollen to be pushed out. This motion takes place when the insect seeks the nectar which is secreted by a ring surrounding

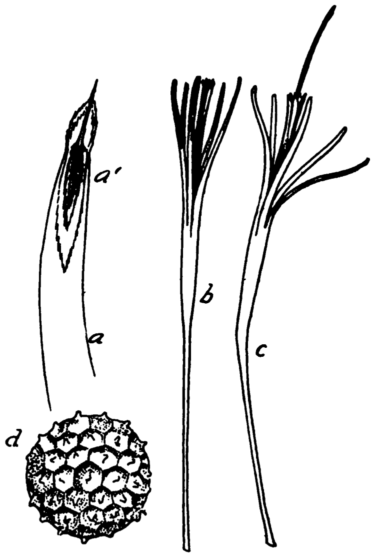


Fig. 12. Pollination of thistle.

a, The outer glandular bract; *a*[1], dorsal glutinous ridge flower with the anthers in the process of lengthening out. *b*, flowers in the male stage before opening. *c*, flower fully mature with the pollen pushed out and the spreading lobes of the corolla. *d*, pollen grains.

the base of the tube of the corolla, which is true, also, in many other *Compositæ*.

Halsted* describes the phenomenon of the sensitiveness of the stamens as follows:

In the thistle these filaments are slender, and are the parts in which motion is induced when the tip or other portion of the flower is touched. These filaments are colorless, and consist of cells from two to three times as long as broad, placed end to end and surrounding a central vascular bundle, consisting of six to ten very small closely coiled spiral vessels. In a cross-section, which is nearly triangular, the cells are seen to be thick-walled; those upon the hypothenuse of the right angle triangle—the inner side of the filament—being larger and thicker-walled than elsewhere. The exterior of this filament bears very many hairs, each always consisting of two nearly parallel cells extending side by side the whole length of the trichome. Usually one cell is longer than the other, and has the tip enlarged above the

*Bull. Io. Agrl. Coll. Dept. Botany, Nov. 1886: 29.

end of its mate. A common hyaline coating covers both the hair cells. These cells do not end at the base of the outgrowth, but one passes up the filaments and the other in the opposite direction, meeting other epidermal cells that are not modified into hairs. The origin of these outgrowths is easy to find. All stages of their development may be seen in any young filament. At first only a slight elevation is observed at the point where two

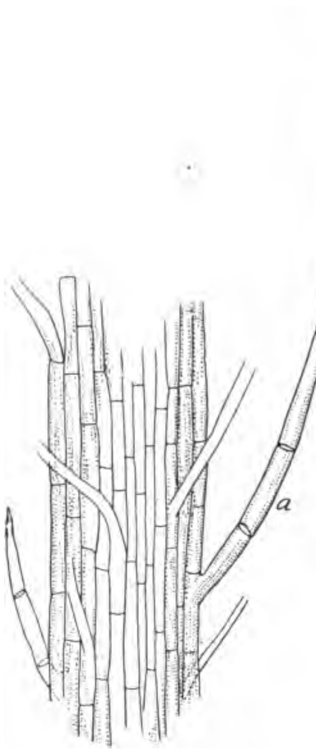
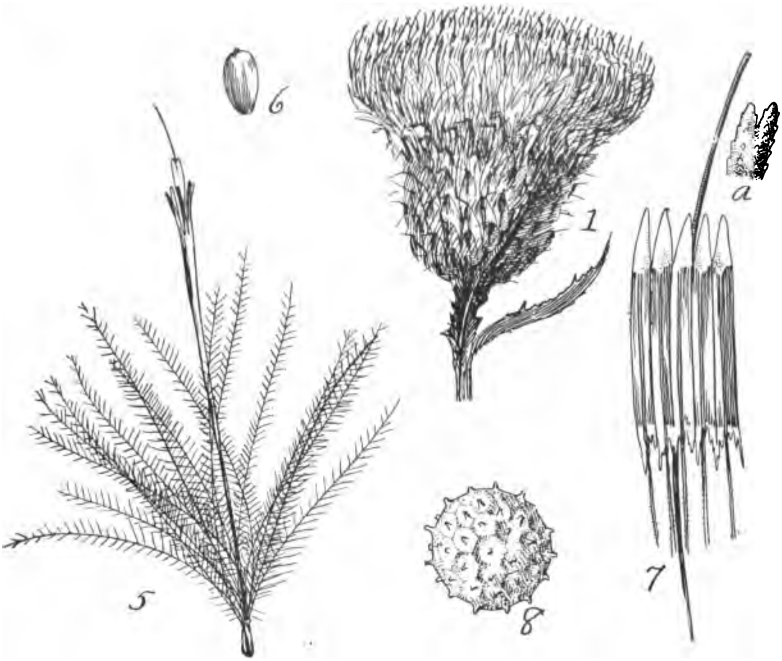


Fig. 13. Plumose bristles, portion of pappus, a single thistle.

epidermal cells join ends. A little later these ends push out side by side, closely appressed, thus making a papilla. Soon after this the lateral portion of each cells equals that which is epidermal. Nearly all the granular contents of both cells are now in the projecting part and the nucleus is prominent. When fully developed the hairs are 20 to 25 u. broad and 1,000 u. long. They are, therefore, the laterally extended tips of adjoining epidermal cells and become triggers, which, when touched by the insect's proboscis, set the filament in motion and cause the drawing down of the tube of anthers. The style, it has been stated, occupies the space within the tube and has its exterior covered with short stiff hairs which point upward. A brush of long upturned hairs is situated at the base of that portion of the style included within the ring of anthers. The anthers dehisce upon the inner side and the pollen comes in contact with the "spiny" surface of

Cnicus undulatus var. *megacephalus*. *1*, head; *2*, outer bracts; *3*, inner bracts; *4*, pappus and flower; *5*, achenium; *6*, stamens, showing sagittate anther sand hairs on filaments; *7*, style. (Miss Charlotte M. King.)



Cnicus canescens, *1*, head; *2*, leaf; *3*, fruit with pappus; *a*, achene; *4*, outer bracts; *5*, inner bracts; *6*, flower; *7*, style; *8*, anthers and filament. (Charlotte M. King.)

the style and falls out into the vacant space in the anther tube above the tip of the style. The upper end of the anther tube opens easily, and any mechanism that will either raise the style or draw down the anther tube would cause the pollen to pass out this terminal pore. The latter method is observed in the thistle. When the conditions are favorable the filaments contract quickly. It frequently occurs that the five filaments do not act at the same time, and this causes the noticeable swaying of the flower. With a needle any particular filament may be touched, and the movements to and

Fig. 14. Leaf *Cnicus undulatus* var. *megacephalus*

fro of the flower governed at pleasure, until the stimulus is transmitted to the other filaments, when the swaying ceases. During this time the anther tube has descended two or three millimetres and a quantity of pollen is pushed out of the pore by the protruding style. The filaments soon readjust themselves and succeeding touches of the flowers by insects or otherwise will bring the anther ring down until the brush of hairs has passed through, when the work of the sensitive structures is accomplished. The style may now elongate, but its surface is smooth from the base of the brush or rosette of stiff hairs, down to its insertion. The two unequal halves of the upper end of the style were not found separated from each other in any of the hundreds examined. There is a deep suture between the two parts near the tip and along this the pollen adheres and germinates. Some observations were made upon the rate of opening of the blossoms in a head. For this purpose heads nearly ready to bloom were placed in water out of the reach of insects. In one head some of the outer flowers were only partly open in the morning. On the evening of the same day one hundred flowers had their anther tubes drawn back and their pollen in sight. The next morning a string was placed between the old flowers and a circle of younger ones that were rising. That evening seventy-four more flowers were in full bloom. A second string was placed around the last circle of flowers. On the third morning fifty-five flowers had their corollas raised above the level of the inner portion of the head. Flowers that are to open upon any day push up about a half inch above their younger associates, in the head, on the previous night. The flowering in a head lasts about a week, the number of blossoms opening daily diminishing from the first day of general blooming. It often occurs that only a few scattered outside flowers will bloom the first day. In such cases the next day is the first of general blooming, when a hundred or more flowers unfold.

The style lengthens and protrudes much beyond the stamens. In the proterandrous stage of course the style is

not visible, but when the pollen is shed it is distinctly visible. The stigma contains the small papillæ along the sides. The nectar in some of the species rises up to the throats of the flowers and numerous insects are therefore attracted to these flowers. In some of the species the proboscis of insects need only be one to one and a half millimeters long to reach the bottom of the throat of the corolla. Mueller says:

> So that the rich store of honeys is accessible not only to bees and Lepidoptera, but to wasps, flies and beetles, which seek it diligently.
>
> But if insects do not visit the flower until the stigmatic edges of the branches of the style have already bent outwards, then self-fertilization is possible, since in this case the hairs of the style still remain covered with pollen. If insects do not visit the flower at all, some of the pollen grains, which hang in little clumps to the hairs, may easily fall of themselves upon the stigmatic papillæ. In fine weather, and in the open air, this can scarcely ever take place, for *Cnicus arvensis* is one of the most abundantly visited of all our native plants. As the following list shows, very few insects resort to it for the sake of its pollen, but very many for its honey.

In regard to the pollinators, the writer has observed many different kinds of bees in Iowa. The bumblebees thrust their proboscis into the long tubular flowers, and so eager are they to get the nectar, that they are easily caught.

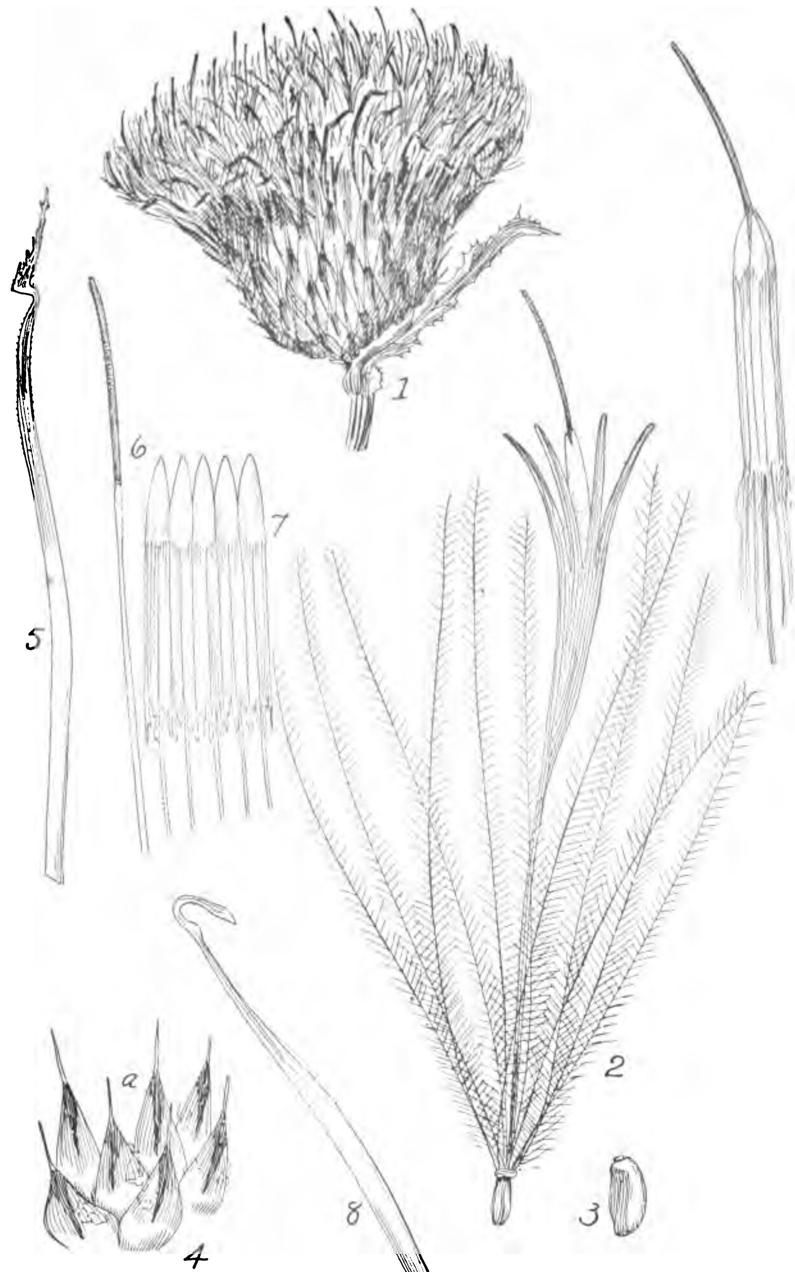
Mr. Weed says:

> Megachile is a frequent visitor, collecting in great quantity the abundant pollen on her abdominal brushes. The beautiful steel blue or green bees of the genus Agapostemon are common, and various smaller species often occur. The two-winged flies of the order Diptera rank next to the Hymenoptera in frequency of visits, although perhaps the butterflies are equally numerous.

Lepidoptera are also common. Of the Lepidoptera, attention may be called to the *Colias philodice*, as well as *Pieris*, *Danais archippus* and *Papilio turnus*. And Mr. Weed notes as follows concerning the pollinators:

> The list of visitors to the common Thistle is an extended one. In conspicuousness, if not also in frequency of visits, the bumblebees take the lead among the *Hymenoptera*. But they are not the large and handsome bees found on the Arbutus in May; they are much smaller in size and less attractive in appearance. This difference is explained by a glance at the life-histories of the bumblebees. The large specimens which appear in spring are the hibernating females or queens, which have passed the winter snugly ensconced in last year's nests, or some sheltered situation.

Cnicus lanceolatus. *1*, head; *2*, leaf; *3*, achene with flower; *4*, stamens and style; *a*, stamens; *b*, style. (Charlotte M. King.)



Cnicus Hillii. *1*, head; *2*, achene with flower; *3*, achene; *4*, outer bracts, *a*, dorsal glutinous ridge; *5* and *8*, inner bracts; *6*, style; *7*, stamens. (Charlotte M. King.)

Mr. Robertson has given quite a full list of the insects found on *Cnicus discolor*, *C. altissimus* and *C. lanceolatus*, at Carlinville, Illinois. According to this writer the following insects are found upon *Cnicus lanceolatus:*

Hymenoptera-*Apidæ: Bombus americanorum* F.; *B. virginicus Oliv.; B. pennsylvanicus* DeG.; *B. separatus* Cr.; *Mellissodes desponsa; M. obliqua* Say; *M. coloradensis; M. bimaculata* Lep.; *M. dentiventris; M. aurigenia* Cr.; *Megachile latimanus* Say; *M. sexdentata* Rob.; *Epeolus remigatus* F.; *Andrenidæ: Halictus ligatus* Say; *H. pilosus* Sm.; *Agapostemon, viridula* F.; *A. radiatus* Say.

Lepidoptera-*Rhopalocera Danais archippus* F.; *Phyciodes tharos* Dru.; *Pieris protodice* B.–L.; *Colias philodice* Gdt.; *Papilio turnus* L. and *P. glaucus* L.; *P. asterias* F.; *P. troilus* L.; *Pamphila peckius* Kby.; *P. cernes* B.–L.; *Eudamus bathyllus* S. and A.; *Heterocera Scepsis fulvicollis* Hbn.

Diptera-Bombylidæ: Exoprosopa fasciata Mcq.; *Systæchus vulgaris* Lw.; *Conopidæ: Physocephala tibialis* Say.

On *Cnicus altissimus* he reports the following:

Hymenoptera-Apidæ: Bombus americanorum F.; *B. pennsylvanicus* DeG; *Mellisodes desponsa.*

Lepidoptera-Rhopalocera: *Argynnis cybele* F.; *Papilio troilus.*

He observed the following visitors upon *Cnicus discolor:*

Hymenoptera-*Apidæ: Bombus separatus* Cr.; *B. scutelaris* Cr.; *B. pennsylvanicus* DeG.; *B. americanorum* F.; *B. virginicus* Oliv.; *Mellissodes desponsa* Sm.; *M. obliqua* Say; *Megachile latimanus* Say; *Andrenidæ: Colletes eulophi* Rob.

Lepidoptera-*Nymphalidæ: Argynnis idalia* Dru.

Diptera-*Bombylidæ Exoprosopa fasciata* Mcq.

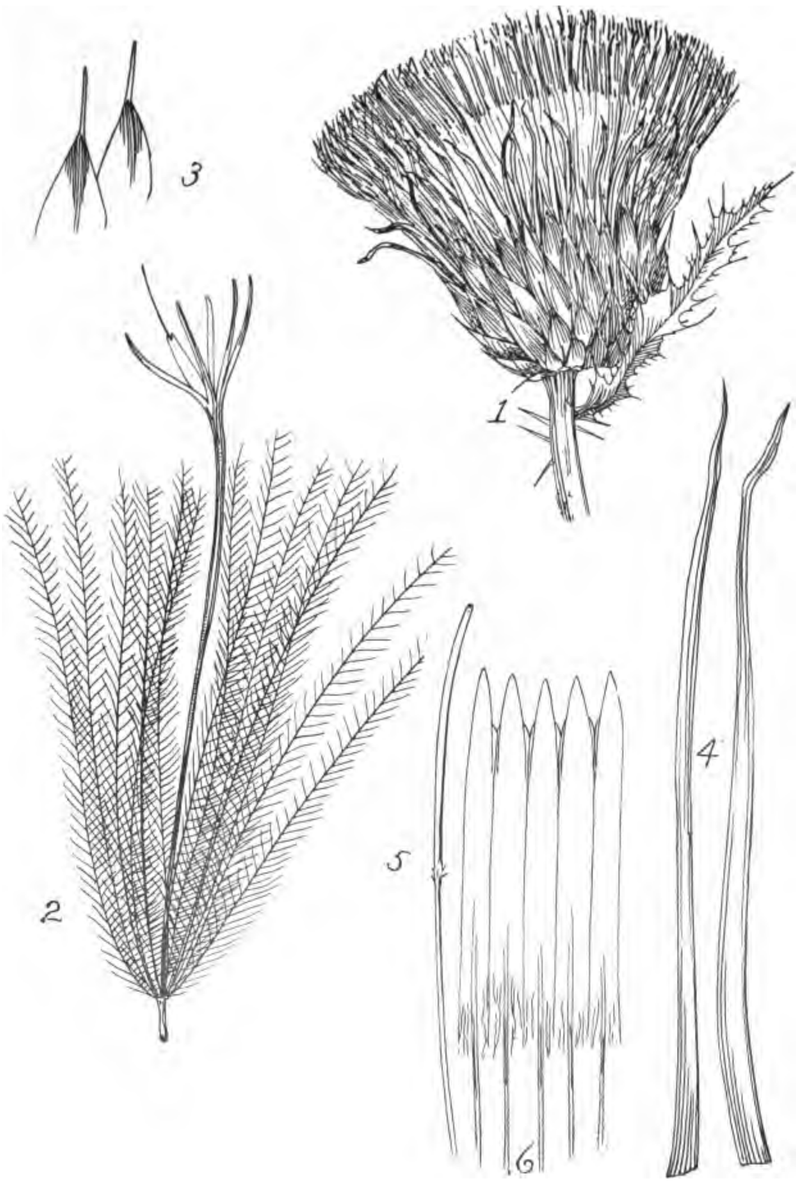
Dissemination.—Not a few writers have discussed the question of the dissemination of the thistles. Among the writers discussing these I may mention Weed "Ten New England Blossoms," Hamilton Gibson "Sharp Eyes," and numerous works dealing with the weedy character of these plants. The fruit of all species has essentially the same structure. The smooth achenes bear at their upper end the limb of the calyx called the pappus, which consists of a large number of plumose bristles. However,

there is a difference with reference to the character of the bristles. In some species the outer flowers are merely barbellate as in *C. muticus* and *C. discolor.* The branches of the pappus are usually clavate. The pappus is so arranged that it forms a neat contrivance for the wind to carry the fruit for a considerable distance from where it was produced. One often can see hundreds of these little downy affairs floating in the air. For this reason so many of the plants make their appearance in clearings, as in pastures and burnt timber. The *Cnicus lanceolatus* frequently occurs in such abundance in pastures as to seriously injure the value of the same for pasture purposes. One sees the same thing in a forest burned over in the course of a year or so in this state The *Cnicus lanceolatus* comes up in abundance. In the Rocky mountain country the *Cnicus drummondii* becomes abundant; in the course of a few years the open woods become covered with these plants, and not inappropriately are sometimes called fire weeds.

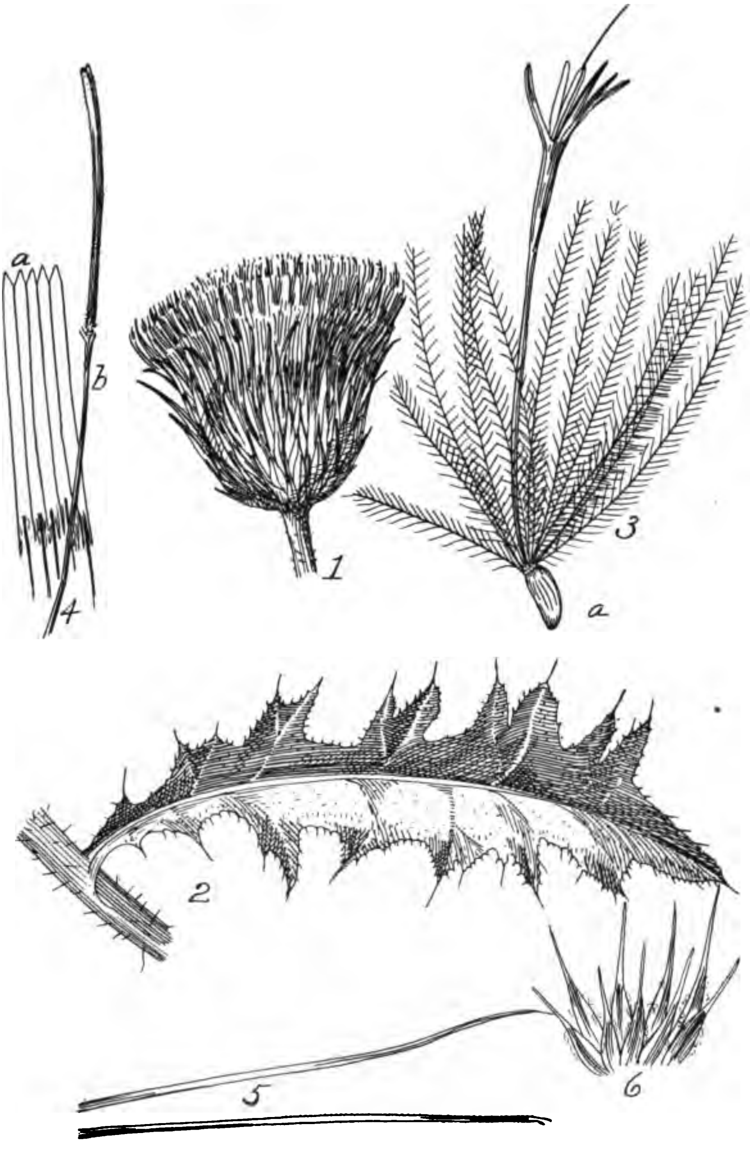
CNICUS.

Cnicus, L. Gen. 6 Ed. 1764. Tourn Inst. 447. *t 255.*
——— Linn. Sp. Pl. 1763. 2 Ed.
——— Willd. Sp. 3: 1662.
——— Bentham & Hooker Gen. Pl. *2*: 468, 1236. 1873.
Cirsium, D.C. Fl. Fr. *4*: 110. 1805. 3 Ed.
——— Prodr. 6: 634. 1837.
——— Hoffmann in Engler and Prantl. Die Nat. Pflanzenfamilien. Theil IV. 5 Abt. 322. 1893.
Carduus, L. Sp. Pl. 820. 1753.
——— Greene. Proc. Acad. Nat. Sci. 1892:
——— Britton and Brown Illustr. Fl. N. St. 3: 484 in part. 1898.

Erect branching or simple caulescent or a few acaulescent herbs, with alternate sessile, or decurrent, decumbent sinuate dentate or pinnatifid spiny leaves, involucre ovoid or globose, bracts of two series, the outer armed with a prickle or without, with a glutinous ridge or none, the inner long acuminate, frequently with a scarious appendage. Large many-flowered, solitary or clustered



Cnicus pumilus. *1*, head; *2*, achene with flower; *3*, outer bracts; *4*, inner bracts; *5*, style; *6*, stamens. (Charlotte M. King.)



Cnicus lanceolatus. 1. Head. 2. Leaf. 3. Flower with pappus and achenium. 4 Anthers and style. 5. Inner bracts of the involucre. 6. Outer bracts.

heads, with whitish, purple or reddish, usually perfect, rarely dioecious flowers; receptacle flat or somewhat convex, bristly. Corolla with a long tube deeply regularily or unequally cleft, stamens with acute anther tips, sagittate at base, filaments usually pubescent, occasionally hairy; style branching, short, with appendage united nearly up to the obtuse tips, with a hairy ring near the tip, bristles of the pappus connate at the base, usually soft plumose, occasionally bristles of outer flowers barbellate; the tips clavate, achenes oblong, obovate compressed, striated, or obtusely 4-angled, glabrous.

In the recent revision of the order it has been customary to place *Cnicus* in with *Carduus* on the basis of the characters found in the pappus, the pappus of *Carduus* being merely barbellate. *Cirsium* is retained by Hoffmann in Engler and Prantl. Pflanzenfamilien. In recent studies of many species the writer has found merely barbellate bristles of the outer flowers, but the subtending leaf-like bracts under the involucre is a further distinguishing feature. The inner bracts have more or less bristly appendages in some of the western species, and in this respect approaches *Centaurea*, although in this genus the pappus consists of aristiform bristles, fimbriolate or of narrow paleæ. It seems to me that these genera should be retained.

Twenty-two species are recorded for oriental Asia by Maximowicz;* and forty-three species for North America, north of New Mexico.†

According to Bentham and Hooker something like 200 species are described, chiefly temperate Europe and Asia and northern Africa and North America, but the number of species has increased somewhat, since the publication of the genera plantarum in 1873. The estimated number now being 250. The total number listed by Heller is seventy-three, whereas in Patterson's check list there are forty-three. It will be seen, therefore, that more than half of the increase in the number of species must be

* Bull. Acad. Petersb. **19**: 489. Mel. Biol. **9**: 301.
† Gray. Syn. Fl. N. Am. **1**: 398.

credited to North America. It is evident that the genus in North America is western, the greater number of species belonging to the Rockies and the Pacific coast.

KEY TO IOWA SPECIES.

1. Flowers hermaphrodite, 2.
1. Flowers imperfectly dioecious .... *C. arvensis*.
2. Outer involucral bracts prickly pointed, 3.
2. Outer involucral bracts slightly pointed or not at all.... *C. muticus*.
3. Leaves hairy underneath, green above.
   a. Involucral bracts all prickly..... .... *C. lanceolatus*
   b. Bracts with a dorsal glutinous ridge.
      ba. Leaves deeply pinnatifid................ ...... *C. discolor*.
      bb. Leaves not deeply pinnatifid, rather small heads.........
      .... *C. altissimus*.
      bc. Leaves usually not deeply pinnatifid, large heads........
      .... *C. Iowensis*.
3. Leaves tomentose both sides, lobes triangular.
      a. leaves deeply pinnatifid, biennial...... .... *C. undulatus*
      b. leaves deeply pinnatifid, perennial............ *C. canescens*.
4. Leaves green, both sides. Inner bract long, acuminate, perennial.. *C. Hillii*.

CNICUS ARVENSIS, Hoffm

Cnicus arvensis, Hoffm. Deutschl. Fl. 1: pt. 2. 130. 1804. 2 Ed.
——— Pursh. Fl. Am. Sept 2: 506. 1814.
——— A. Gray. Syn. Fl. N. Am. 1: 398. 1884.
——— Watson & Coulter. Gray's Man. 296. 1890. 6 Ed.
Cirsium arvense, Scop. Fl. Carn. 2: 126. 1772. 2 Ed.
——— DeCandolle. Prodr. 6: 643. 1837.
——— Torrey & Gray. Fl. N. Am. 2: 460. 1848.
——— Gray Man. 274. 1868. 5 Ed.
Serratula arvensis, L. Sp. Pl. 820. 1753.
Carduus arvensis, Robs. Brit. Fl. 163. 1777.
——— Britton & Brown Illust. Fl. N. St. 3: 489. *f. 4071*. 1898.

Smooth perennial, spreading by creeping root-stocks, one to three feet high, corymbosely branched at the top; stem smooth; leaves lanceolate, sessile, and deeply pinnatifid, lobes and margins of leaf with spiny teeth; heads small, three-fourths to an inch high, bracts appressed, the outer with a broad base, inner narrow, all with an acute tip, never spiny, somewhat arachnoid; flowers purple, dioe-

Cnicus arvensis.

Cnicus lanceolatus.

Cnicus ochrocentrus.

Cnicus altissimus.

Cnicus discolor.

Cnicus discolor.

cious, in staminate plant flowers exserted with abortive pistils, in pistillate less so, scarcely exceeding the bracts stamens with abortive anthers, tubes of the corolla six lines long, anther tips acute, filaments minutely pubescent, young achenium pubescent, all of the bristles of the pappus plumose.

Distribution, Iowa.—Houston County, Minnesota, Minnesota and Iowa line, L. H. Pammel, No. 581, I. S. C. Bedford, A. G. Lucas. Ames, E. R. Hodson. Lawler, P. H. Rolfs. Near Tama City, C. E. Arnold. Decatur and Johnson Counties, T. J. and M. F. L. Fitzpatrick. Johnson County, Emma G. Linder. Moscow and Muscatine, Ferd. Reppert. Keokuk, Lee county; Cedar Rapids, Linn County, and Johnson county, Shimek.

REFERENCES TO OCCURRENCE IN THE STATE.

Arthur, Contr. Fl. Ia. 1: 20; Bessey, Contr. Fl. Ia. 109; Hitchcock, Cat. Anth. and Pterid. Ames. 505; Fink, Sperm. Fl. Fayette. Ia. 94; Fitzpatrick, Fl. So. Ia. 152; Man of Fl. Pl. Ia. 95; Nagel and Haupt. Phaen. of Davenport. 159; Pammel, Weed Pests. Ia. Agrl. Exp. Sta. 13: 73;—Weeds of Cornfields. 44, *2 f.*; Barnes, Reppert, and Miller, Fl. Scott and Muscatine Counties. 234; Halsted, Prel. List of Ia. Weeds. 42.

CNICUS MUTICUS, Pursh.

Cnicus muticus Pursh. Fl. Am. Sept. 506. 1814.
——— Ell. Sk. **2**: 268. 1824.
——— Gray. Proc. Am. Acad. **10**: 39. 1874.
——— Gray. Syn. Fl. N. Am. **1**: 405. 1884.
——— Watson & Coulter. Gray's Man. 296. 1890. 6 Ed.
Cnicus glutinosus, Bigel. Fl. Bost. 291. 1824. 2 Ed.
Cirsium muticum, Michx. Fl. Bor. Am. **2**: 89. 1803.
——— DeCandolle. Prodr. **6**: 652. 1837.
——— Torrey and Gray. Fl. N. Am. **2**: 458. 1843.
——— Gray. Man. 1868. 274. 5 Ed.
Cirsium bigelovii, D.C. Prodr. **6**: 652. 1837.
Carduus muticus, Pers. Syn. **2**: 386. 1807.
——— Britton & Brown. Illust. Fl. N. St. **3**: 489. *f. 4070* 1898.

Tall branching perennial, three to eight feet high, stem striate, smooth with age, few leaved, branches bearing few medium-sized heads with purple flowers; leaves deeply pinnatifid, divisions lanceolate, the principal lobes somewhat spiny, upper surface slightly roughened, lower decidedly arachnoid, woolly when young, less so with age; heads one to one-fourth inches high, scales of the involucre closely appressed, cobwebby, outer with a broad base and a glutinous line on back, inner long acuminate, appendage with serrated margins, flowers purple, tube seven and one-half lines long, lobes three lines long, anthers with acute tips, appendage pubescent, filaments hairy, bristles of pappus of outer flowers barbellate, inner plumose, achenes one and three-fourths lines long, smooth.

Distribution, Iowa.—Mason City, Forest City, Winnebago county, Shimek. S. U. I.

REFERENCE TO OCCURRENCE IN THE STATE.

Arthur, Contr. Fl. Ia. 1: 20.

CNICUS DISCOLOR, MUHL.

Cnicus discolor. Muhl. Willd. Sp. 3:1670. 1804.
———— Ell. Sk. 2: 271.
———— C. altissimus, var. discolor. Gray. Proc. Am. Acad. 1: 40. 1884.
———— Watson & Coulter. Gray's Man. 296. 1890. 6 Ed.
Cirsium discolor, Spreng. Syst. 3: 373. 1826.
———— DeCandolle. Prodr. 6: 640. 1837.
———— Torrey & Gray. Fl. N. Am. 2: 457. 1843.
———— Gray. Man. 273 1868. 5 Ed.
Carduus discolor, Nutt. Gen. 2: 130. 1818.
———— Britton & Brown. Illustr. Fl. N. St. 3: 485. *f. 4060.* 1898.
Serratula discolor, Poir. Dict. Enc. 6: 565.

Tall, branching, leafy perennial, five to seven feet high, with heads larger than *C. altissimus*, stem striate, slightly hirsute; leaves radical, twelve to fourteen inches long, deeply pinnatifid, the divisions frequently divided, prickly toothed, the upper surface slightly hirsute, the lower woolly, stem leaves deeply pinnatifid, linear or linear-lanceolate with falcate segments, the larger twice or thrice cut, tipped with prickly spines, upper surface smoothish, the lower white, woolly; single heads terminating the branches, with purple flowers; heads one and one-half inches high; bracts of the globose involucre somewhat appressed, slightly arachnoid,

Plate xxvi.

Cnicus Iowensis var. *Crattyi* type.

Cnicus Iowensis.

Cnicus altissimus

Cnicus Iowensis.

Cnicus Iowensis.

Cnicus Iowensis var. *Crattyi.*

lower bracts ovate with a broad base and a weak prickly recurved bristle, slight dorsal gland, inner linear lanceolate with a nearly colorless entire appendage; flowers purple, tube of the corolla nearly eleven to twelve lines long, lobes of the corolla terminating in clavate tips, anther tips acute, filaments pubescent; bristles of pappus plumose; achenium twenty-two lines long, smooth, upper part yellow.

The species is certainly fairly constant and may usually be readily separated from typical *C. altissimus* and *C. Iowensis*. In the character of its head it approaches *C. Iowensis*, but the more numerous segments of the smaller leaves separates it from that species. It is certainly markedly different from *C. altissimus*. Frequent along roadsides and in timber.

Distribution.—Ames, Pammel & Combs. No. 68; Fred Rolfs. Keokuk, P. H. Rolfs. Johnson County, Oct., 1893, T. J. & M. F. L. Fitzpatrick. Muscatine, Iowa, Ferd. Reppert. Winnebago County, B. Shimek, S. U. I. Skunk River Valley, Lee County, Paul Bartsch. Muscatine County, Reppert, 435.

Mr. Reppert reports a white-flowered form along the Cedar river.

REFERENCES TO OCCURRENCE IN IOWA.

Arthur, Contr. Fl. Ia. 1: 20; Barnes, Reppert, and Miller, Fl. Scott and Muscatine Cos. 234. Hitchcock Cat. Anth. and Pterid. Ames, 505. Pammel Notes on the Fl. West Ia. 125. Weeds of Cornfields. 39: 42. *2f.* Halsted Prel. List of Iowa Weeds. 42; Fink, Sperm. Fl. Fayette Ia. **94**; Fitzpatrick, Fl. S. Ia. 152; Man. Fl. Pl. Ia. 95.

CNICUS ALTISSIMUS, Willd.

Cnicus altissimus, Willd. Sp. 3: 1671.
——— Ellis. Sk. 2: 268. 1824.
——— Gray. Proc. Am. Acad. **10**: 42. 1874.
——— Gray. Syn. Fl. N. Am. **1**: 404. 1884.
——— Watson & Coulter. Gray's Man. 296. 1890. 6 Ed.
Cirsium altissimum, Spreng. Syst. **3**: 373. 1826.
——— DeCandolle. Prodr. **6**: 640. 1837.

——— Gray. Man. 68. 5 Ed.
Carduus altissimus, L. Sp. Pl. 824. 1753.
——— Britton & Brown Illustr. Fl. N. St. 3: 485. *f.* 4059. 1898.

Tall, widely branched, biennial, five to ten feet high, stems hairy when young, becoming smoothish or with a few scattered bristles when old, rather small heads terminating the branchlets; leaves, radical—a foot or more long, ovate or oblong, nearly entire or spinulose, the upper with a few prominent or spinulose teeth or somewhat pinnatifid, upper surface slightly rough, and lower woolly; arachnoid heads one and one-fourth to one and one-half inches high; bracts of the involucre arachnoid when young, the outer with a broad base and a black gland running down the back, tipped with a weak spreading bristle, inner bracts much longer than the outer, terminating in a colorless recurved triangular tip with a serrated margin, tube of the corolla eight to nine lines long, filaments pubescent, anther tips acute, anchenium smooth, two and one-fourth lines long, bristles of pappus all plumose.

This species is at once distinguished from *C. Iowensis* and *C. discolor* by its much smaller heads, less deeply pinnatifid leaves, and the smaller number of branches. It is the tallest of all our thistles, and always grows in forests or on the border of woods. It extends to the Mississippi and some of the immediate tributaries. It rarely occurs in the interior of the state. Common in the eastern states, extending southwest to Missouri and Arkansas, in the timbered regions of the Mississippi Valley.

Distribution.—Clinton, Lyons, No. 66, L. H. Pammel. Dubuque, Iowa, L. H. Pammel. Jasper County, H. W. Norris.

The following specimens examined by me are typical:

Iowa—Johnson County, Decatur County, T. J. & M. F. L. Fitzpatrick. Muscatine County, Ferd. Reppert. Ames, Hitchcock. Galva, F. R. S. Aby, S. U. I. Iowa City, T. H. Macbride. Johnson County, B. Shimek.

REFERENCES TO OCCURRENCE IN IOWA.

Arthur, Contr. Fl. Ia. 1: 20. Bessey, Contr. Ia. Fl. 109. Nagel & Haupt, Phaen. of Davenport 159. Barnes, Reppert, and Miller, Fl. Scott and Muscatine Counties 234; Halsted, Prel. List Ia. Weeds 42; First Blooming of Spring

Cnicus filipendulus.

Cnicus undulatus var. *megacephlus.*

Cnicus undulatus.

Cnicus canescens (Gray Herb.)

Cnicus Nelsoni type.

Cnicus canescens.

Pl. 52; Fink, Sperm. Fl. Fayette Ia. 94; Fitzpatrick, Fl. N. E. Ia. 121. Fl. of S. Ia. 152.—Man. Fl. Pl. Ia. 95.

CNICUS IOWENSIS, Pammel n. sp.

Plants three to four feet high, bearing large heads with purple flowers; stem striate, hirsute or nearly glabrous, roughened; leaves, the upper lanceolate with prominent spinose teeth shallowly lobed or occasionally deeply lobed, the lower lobes prominent, upper surface rough with a few spreading hairs, lower surface floccose, woolly; heads large, one and three-fourths to two inches high; involucre somewhat arachnoid, outer scale ovate with a weak spreading bristle, and a prominent glutinous dorsal ridge, the inner long, linear lanceolate with an erose appendage; flowers purple, corolla tube eleven lines long, lobes with clavate tips, anther tips acute, filaments with shaggy hairs, bristles of pappus plumose, achenium smooth, upper part yellow, striate, two and one-fourth lines long. Type No. 65 (I. S. C. Distr.) Ledges Boone County, Iowa. Pammel. Type specimens in Herbarium I. S. C. Gray Herbarium and Missouri Botanical Garden. Kossuth Co., 606. Pammel. Ontario (E. R. Hodson).

Distribution, Iowa.—Ledges, Boone Co., 65, Pammel and Ball (not *C. altissimus*). Ames, 694, Pammel. Eagle Grove, Pammel. Spirit Lake, Little Rock, C. R. Ball. Ontario, E. R. Hodson. Kossuth Co., 606 I. S. C., Pammel. Emmet Co., R. I. Cratty. Rock Creek Twp., Jasper Co., H. W. Norris. Decatur Co., T. J. & M. F. L. Fitzpatrick. Atlantic, Wagner, S. U. I. Iowa City, Lindner. Granite, Lyons Co., B. Shimek. Council Bluffs, Dubal and Cavanagh, S. U. I. Coll. Logan Twp., Calhoun Co., G. B. Rigg. Armstrong, Emmet Co., B. Shimek.

Kansas.—Manhattan, (Coll.?).

South Dakota.—Opposite Hawarden, Iowa, Pammel.

REFERENCE TO OCCURRENCE IN IOWA.

Hitchcock, Cat. Anth. & Pterid. Ames, 505; under *C. altissimus.*

Cnicus Iowensis variety *Crattyii.* Pammel n. v.

The variety differs from the type in the fact that the leaves are usually less deeply cut. The heads are smaller, and the stem, as well as the leaves, more or less canescently tomentose. Named in honor of R. I. Cratty, who has carefully studied the flora of Iowa for many years.

Distribution.—Emmet County. (Herb. S. U. I.) Little Rock, Spirit Lake, C. R. Ball.

CNICUS UNDULATUS, A. GRAY.

Cnicus undulatus, A. Gray. Proc. Am. Acad. **10**: 42. 1874.

———. A. Gray. Syn. Fl. N. Am. **1**: 403. 1884.

Cirsium undulatum, Spreng. Syst. Veg. **3**: 374.

———. DeCandolle, Prodr. **6**: 651. 1837.

———. Torrey & Gray, Fl. N. Am. **2**: 456. 1843.

———. Gray Man. 273. 1868. 5 Ed.

Carduus undulatus, Nutt. Gen. **2**: 130. 1818.

———. Greene. Proc. Acad. Nat. Sci. **1892**: 359.

———. Britton & Brown. Illustr. Fl. N. St. **3**: 486. *f 4063.* 1898.

Low biennial two to four feet high, white woolly, branches bearing a single head with purple flowers; stem striate, white woolly, or somewhat glabrate below; leaves, the lower eight inches to a foot or more long, undulate, lobed or pinnatifid, with prickly dentate lobes, upper surface at first arachnoid later smoothish; lower densely canescent with prominent veins connecting with spinescent tips, upper sessile, lanceolate or oblong-lanceolate, deeply pinnatifid, to spinescently lobed; heads one and three-fourths to two inches high, flowers purple; bracts of the involucre appressed, arachnoid, outer ovate to lanceolate with a rather weak prickle and a thick glutinous ridge on back, inner bracts long, lanceolate acuminate, straw colored and serrate, flowers purple, corolla tube ten lines long, the corolla lobes four lines long, tips clavate, anther tips strongly acute, filaments pubescent; achenium smooth, pappus of outer flowers merely barbellate, the inner plumose.

This is an extremely variable species. Its distribution is said to be from Lake Huron, calcareous islands to the Northwest territory and to British Columbia and Oregon. The species is certainly not common east of the Missouri. In company with Mr. Cratty the writer found what undoubtedly should be referred to his species in Kossuth County. No. 607 (I. S. C.).

This is not typical for the species, but in its habit of growth and character of leaves more nearly approaches this than *C. canescens*. It is certainly not *C. altissimus* var *filipendulus*.

Cnicus Plattensis var. *spinosior.*

Cnicus Plattensis.

Cnicus Plattensis from Wy.

Cnicus Hillii.

Cnicus pumilus. (Gray Herb.)

Cnicus muticus.

This species is common in Nebraska and Colorado, but in western Nebraska, Kansas and Colorado the species has a tendency to vary into the var. *megacephalus.*

Distribution.—Kossuth County, Pammel, 607 I. S. C. Also reported from Muscatine County.

REFERENCE TO OCCURRENCE IN IOWA.

Barnes, Miller, and Reppert, Fl. Scott and Muscatine Counties. 234.

CNICUS UNDULATUS, VAR. MEGACEPHALUS, A. GRAY.

C. undulatus var. *megacephalus.* A. Gray. Proc. Am. Acad. 10: 42. 1874.
——— ———. Syn. Fl. N. Am. 1: 403. 1884.
Carduus undulatus megacephalus. (A. Gray.) Porter Mem. Tor. Bot. Club 5: 345. 1894.
Britton & Brown, Illustr. Fl. N. St. 3: 486. 1898.

Branches bearing single large heads with purple flowers two to two and one-half inches high, involucre more or less strongly appressed, scales with a prominent glutinous ridge, achenium four lines long. striate.

Distribution, Iowa.—Boone, introduced, G. W. Garver.

CNICUS CANESCENS, PAMMEL n. c.

Cnicus undulatus var. *canescens.* Gray. Proc. Am. Acad. 10: 42. 1874.
———. Gray. Syn. Fl. N. Am. 1: 403. 1884.
Cirsium canescens. Nutt. Trans. Am. Phil. Soc. 7: 420.
———. Torrey & Gray. Fl. N. Am. 2: 461. 1843.

Branching perennial two to four feet high, woolly throughout, branches bearing single medium-sized heads. stem angled, white woolly; leaves, radical eight inches to a foot long, the divisions usually two-lobed, prominently ribbed, ending in stout spines; stem leaves, except the lower, one to four inches long. pinnatifid, the upper sessile, slightly undulate with numerous sharp bristles, the upper surface slightly roughened, and a slight cottony down, the lower white woolly; heads one one-half to two inches high, bracts of the involucre somewhat arachnoid, lower scales with a broad base, glutinous ridge, and ending in a minutely serrated spine, inner scales long attenuated, tips straw-colored; flowers purple.

corolla tube ten one-half lines long, anther with very acute tips, achenium one and one-half lines long, pappus plumose.

A specimen in the Engelmann Herbarium as well as several in the Gray Herbarium, are ticketed *Cirsium canescens.*

In the Gray Herbarium is a specimen ticketed *Cirsium undulatum β*, Torrey and Gray, Flora of North America, (2: 456), collected by Mr. Charles A. Geyer, in August, 1839, and labeled "Fertile prairies, near Devil's Lake, the only specimen found; please return it to Mr. Nicollet after examination." There is a note by Dr. Gray: "Not improbably our *C. undulatum* var. *β.*"

Dr. Gray, in his revision of the genus *Cnicus* for the Synoptical Flora of North America (': 403) says:

Var. *canescens*, Gray, is merely a form with smaller heads, sometimes not over an inch high, leaves varying from ciliately-spinulose dentate to deeply pinnatifid. *Cirsium canescens* and *C. brevifolium*, Nutt. Trans. Am. Phil. Soc. 7: 421—Minnesota to Mexico and S. Utah.

Another specimen is ticketed "*Cirsium hookerianum saskatchawan*, collected by Bourgeau, in 1858, in Palliser, Brit. N. A. Exp." Another specimen of the Rocky Mountains, by Burt, in 1849; this was referred by Dr. Gray to *C. undulatus* in the Syn. Fl. N. A. (1: 403). One specimen each in the Gray and Engelmann Herbarium, is ticked "*C. canescans*, Nutt. Collected by Dr. Hayden on the Upper Platte." This in the Gray Herbarium is placed under the variety *canescens* by Dr. Gray. Rydberg correctly considered it as distinct, and referred his form to *Carduus plattensis spinosior;* this specimen is clearly a form of Rydberg's *C. plattensis.*

The Fendler specimen, No. 73, collected near Fort Kearney, also belongs here. This species seems to be quite common in the Sand Hill region of Nebraska. This species and the *Cnicus Nelsoni* are closely allied to *Cnicus Pitcheri.*

In the Gray Herbarium is a specimen marked "*Cnicus altissimus*, Willd. var. *filipendulus*, Gray. Sandbars of Missouri river. Sioux City, Iowa, Hitchcock." Dr. Sereno Watson having referred our Iowa material to the variety

C. filipendulus, Prof. A. S. Hitchcock has a note in Botannical Gazette referring to the distribution of this species, supposing it to be southern.

The *C. filipendulus* (*Cirsium filipendulum*, Engelmann), I believe is a good species. It is marked by its tuberous roots and deeply pinnatifid and spiny leaves. This species more nearly approaches *C. discolor.* It is not canescently tomentose as *C. canescens.*

Distribution.—I would refer the following to *C. canescens*, No. 67, Sioux City, Pammel; northwest Iowa, Sept., '95, Pammel; Sioux City, Hitchcock; Sioux City, Pammel; Armstrong, Emmet County, Cratty; Montana, John Craig. The writer has seen this abundantly in the vicinity of Sheridan, Wyoming.

It is the only one of our native species that occurs in patches. It is undoubtedly perennial; specimens in our herbarium from Montana by Professor Craig, show it to come from a deep seated root; and likewise, in the Gray herbarium. The writer has received the species quite frequently during the past four years from northwest Iowa, in which this opinion was expressed by those sending it.

REFERENCES TO OCCURRENCE IN IOWA.

Hitchcock, Notes on the Fl. of Ia. Bot. Gazette. 14: 129. Pammel as *C. undulatus* and *C. altissimus* var. *filipendulus* in Notes on the Fl. of West Iowa. 124.

CNICUS NELSONI n. sp., PAMMEL.

A branching biennial, plants from two to three feet high, somewhat hairy, bearing numerous ochroleucus heads, which terminate the branches. Stem, prominently striated, white woolly at first, becoming smoothish with age. Leaves radical, five to six inches long, deeply pinnatifid, the prominent lobes with yellow spines, lower surface densely tomentose, upper woolly, becoming glabrate with age. The stem leaves sessile and decurrent, the upper two to six inches long, with prominent spiny lobes. The spine is yellowish. Leaves more or less canescently tomentose, upper surface arachnoid, woolly, becoming smoothish with age. Heads, one to one and a fourth inches high, rarely one and a half. Involucre somewhat turbinate. The bracts with a prominent glutinous ridge tipped with a yellow spine, outer bracts ovate-lanceolate, inner long acuminate and straw colored, tips minutely serrated. Flowers

ochroleucus, tubes of the corolla eight and one-fourth to one-half lines long, lobes three and a half lines long, strongly clavate, anther tips acute, bases sagittate, filaments hairy. Achenium light brown throughout, with dark longitudinal striæ. Pappus of outer flowers merely barbellate, inner plumose with strongly clavate tips.

Type No. 8093, Laramie, Wyoming, Nelson. Laramie, Wyoming, No. 871, from similar locality, should also be referred to it, although the latter number approaches *C. plattensis-spinosior*, except with reference to the size of heads, which in *C. plattensis-spinosior* are somewhat larger. Professor Nelson's 8093 is taller and much less canescently tomentose with age. The species is named in honor of Prof. Aven Nelson, who has done so much for the botany of Wyoming.

Cnicus Hillii, Canby.

Cnicus Hillii, Canby Gard. and Forest. **4**: 101. 1891.
C. odoratus, Muhl. C. odoratus, Muhl. Cat. 1 Ed., Hitchcock Cat. Anth. & Pter. of Ames. 505.
Carduus Hillii, Canby. Porter. Bull. Torr. Bot. Club **5**: 344. 1894.
———. Britton & Brown Illustr. Fl. N. St. **3**: 488. *f 4068*.1898.

Low, sparingly branched perennial; root fusiform, tuberous, eight to twelve inches long; one to two feet high, with purple flowers; stem woolly, the branches bearing single heads; radical leaves,

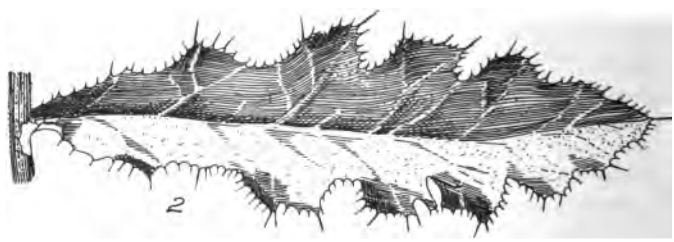


Fig. 15. Cnicus Hillii.

variable, long; stem leaves, lower spatulate, oblong, with spinulose margins to the point of attachment, upper sessile and clasping, usually pinnatifid, lobes broad and rounded, acute or obtuse, with spinulose teeth and stout bristles, leaves slightly hairy on lower surface, upper smoothish; heads two one-half inches high, outer bracts of the involucre ovate lanceolate with a prominent dorsal glutinous ridge,

tipped with a soft bristle, inner long acuminate, narrow lanceolate ending with an erose appendage.

Distribution, Iowa.—Ames, Ball, Combs. Gilbert Station, G. W. Carver. Ontario, E. R. Hodson. Dubuque, L. H. Pammel. Muscatine, Ferd. Reppert. Ames, Hitchcock, S. U. I. Mason City, B. Shimek. Des Moines, Pammel. North English, W. D. Fitzwater.

The specimens collected by A. S. Hitchcock at Ames have large heads and large flowers with the scarious erose bracts and acuminate anther tips. The basal outer bracts are very large. And in its genaral characters resembles specimens collected by Mead in Illinois and Westchester, Darlington and Trelease at Ithaca, N. Y., and by Engelmann in the American bottoms opposite St. Louis.

After an examination of a considerable amount of material I find that there is a great deal of morphological variability in *Cnicus Hillii* and *C. odoratus*. The *Cnicus Hillii* seems to be quite variable, which is evidenced by the careful drawings of Messrs. Barnes, Reppert, and Miller. But in their figures the inner bracts are simply long acuminate. All the Muscatine specimens that I have examined reveal the fact that the inner bracts are not only long acuminate, but are erose; this seems to be true of all the specimens of this species which I have examined. It is a good character. A specimen collected by William Boot in Cambridge, Mass., and preserved in the Gray Herbarium, is typical of *C. odoratus;* this has the appendages long acuminate, but not erose. It is possible, of course, that the *C. odoratus* may reach the state of Iowa, but it is doubtful. It seems to be an Atlantic coast species.

REFERENCE TO OCCURRENCE IN IOWA.

Arthur, Contr. Fl. Ia. 1: 20. Hitchcock as Cnicus odoratus, Muhl, Cat. Ant. & Pter., Ames. Barnes, Reppert, and Miller, Fl. Scott and Muscatine Cos. 234, 281, *pl. 1–2.* Halsted, Prel. List Ia. Weeds 42. Fitzpatrick, Man. Fl. Pl. Ia. 95.

CNICUS LANCEOLATUS, Willd.

Cnicus lanceolatus, Willd. Prodr. Fl. Berol. 259. 1787.
———. A. Gray. Syn. Fl. N. Am. 1: 398. 1884.
———. Watson & Coulter. Gray's Man. 295. 6 Ed. 1890.
Cirsium lanceolatum, Scop. Fl. Car. 2: 130. 1770. 2 Ed.
———. DeCandolle. Prodr. 6: 636. 1837.
———. Torrey & Gray. Fl. N. Am. 2: 456. 1848.
———. Gray. Man. 1868. 5 Ed.
Carduus lanceolatus. Linn. Sp. Pl. 821. 1753.
———. Britton and Brown. Illustr. Fl. N. S. 3: 485. *f. 4058*. 1898.

Branching biennial, three to four feet high, tomentose when young, becoming dark green and villous or hirsute with age, branchlets bearing large heads; leaves lanceolate, decurrent on the stem with prickly wings deeply pinnatifid, the lobes with rigid prickly points, upper face roughened with short hairs, lower face with a cottony tomentum; heads one and three-quarters to two inches high, bracts of the involucre lanceolate, rigid when young, more flexible with age, long attenuated prickly pointed spreading tips, arachnoid woolly; flowers hermaphrodite, tube of the corolla ten lines long, anther tips acute, filaments pubescent, achenes smooth one and a half lines long, pappus of numerous plumose bristles.

Distribution, Iowa.—Troublesome weed in pastures and along roadsides in all parts of the state, most abundant in clearings. Ames, Emma Sirrine, No. 232; Fred Rolfs. Glendon, O. P. Miller. Keokuk, P. H. Rolfs. Des Moines, L. H. Pammel. Johnson County, Van Buren County, Decatur County, Appanoose County, T. J. & M. F. L. Fitzpatrick. Muscatine Iowa, Ferd. Reppert. Skunk River Valley, Lee County, Bartsch. Johnson County, B. Shimek. Ames, P. H. Rolfs. Grand Junction, H. Johnson, Guthrie County, H. Johnson.

REFERENCES TO OCCURRENCE IN IOWA.

Arthur, Contr. Fl. Ia. 3; 259; Bessey, Contr. Fl. Ia. 109; Hitchcock, Cat. Anth. Pterid. Ames, 504; Barnes, Reppert, and Miller, Fl. Scott and Muscatine Cos. 234; Fink, Sperm. of Fayette, Ia. 94; Nagel & Haupt, Phaen. of Davenport,

159; Pammel, Weed Pests, Bull. Ia. Agrl. Exp. Sta. 13: 72; Notes on Some Intr., Pl. 114; Some Obnoxious Weeds, 445, *pl 3*; Weeds of Cornfields 41, *2 f.;* Halsted, Prel. List Ia. Weeds. 42; Fitzpatrick, Fl. N. E. Ia. 120.

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Pammel L. H. Notes on the Flora of Western Iowa. Proc. Ia. Acad. of Sci., 3: 106-135. Contr. Bot. Dept. I. S. C. of Agrl. & Mch. Arts. 1.

———. Weeds of Cornfields. Bull. Agrl. Exp. Sta. I. S. C., Agrl. & Mech. Arts. 39. *22 f.*

———. Notes on Some Introduced Plants of Iowa. Proc. Ia. Acad. of Sci. 4: 110-118. Con. Bot. Dept. I. S. C. A. Mech. & Arts. 4: 1897.

———. Weed Pests. Bull. Ia. Agrl. Exp. Sta. 13: 72.

———. Some obnoxious weeds of Iowa. Rep. Ia. State Agl. Soc. ——— 436—450. *4 pl. 1. f.*

BACTERIOLOGICAL INVESTIGATION OF THE IOWA STATE COLLEGE SEWAGE.

L. R. WALKER.

INTRODUCTION.

As an introduction to the consideration of the Iowa State College sewage, the kinds of sewage, the necessity of disposal, and several of the most important methods with their merits and disadvantages will be discussed.

It has been my object in the following paper to bring together the data obtained from the bacteriological analysis of the college sewage, including daily samples from the effluent and weekly samples from the manhole and tank. Together with this data are given the daily temperatures of the air and of the sewage, at the time of taking samples; also, the soil temperatures, which were taken once a week.

Besides this data it has seemed desirable to give the methods employed in the determination of the number of bacteria per cubic centimeter of the sewage.

And lastly, a partial interpretation of the results obtained, has been attempted, special attention having been given to the percentage of gas producers present in the manhole, tank, and effluent, and to the fluctuations, during the different days and seasons, of the number of bacteria per cubic centimeter in the samples from the manhole, tank, and effluent. The determination of the species of bacteria present in the sewage has not been attempted, only incidentally.

From a sanitary point of view there is no question of more vital importance than the proper disposal of sewage. The lack of such disposal brings a multitude of evils,

which often culminate in prolonged illness, or even death; not only is waste of all kinds a menace to the public health, but it is also a repulsive sight to the æsthetic tastes of any civilized community. This last factor alone would make sewage disposal a question of considerable importance, as the value of property depends to a considerable extent upon its attractiveness, and anything which takes away from its good appearance deducts from its market value.

The question of sewage disposal is coming to be recognized by the officers of the state boards of health in the various states. Perhaps, as leaders in this movement, may be mentioned Massachusetts, Connecticut and Maryland. The State Board of Health of Iowa (14), in its annual report for 1899, called especial attention to the almost utter lack of adequate means of sewage disposal in the small towns and cities of the state, and urges that some action be taken toward securing proper sewage disposal.

In considering the question of sewage disposal it may be well to define what is meant by sewage. Sewage, according to Barwise (3), comes from the Anglo-Saxon word seon, which means to flow down and includes the liquid contents of a sewer. Rafter and Baker (5), however, give sewage as including not only the combined water and waste matters flowing in sewers, but the mixed solids and liquid matter. This latter, it seems, is a better definition as it includes the solid excreta as well as the matter in solution.

The kinds of sewage will necessarily vary with the imposed conditions. The most common may well be termed domestic sewage, which contains kitchen slops and all the common refuse of ordinary dwellings. Factory sewage is more complex in most cases, depending, of course, upon the particular kind of factory under consideration. Packing house sewage would hardly come in this category, yet it plays a very important part in sewage disposal on account of its peculiar constituents. Surface sewage, if such it may be called, is composed chiefly of water, and the washings from the streets, alleys, etc. City sewage being

essentially a compound of all the above mentioned, with the addition of others not enumerated, make it very complex and hard to deal with, as the plan adopted must needs be one which takes into account all its peculiarities and treats it accordingly.

After what has been written on the subject of the necessity of sewage disposal it seems almost needless to try to add anything new. Yet it may be of interest to make a brief review of the already published facts. That sewage is a source of contamination and disease has long been established, many cases of typhoid fever have been directly traced to the lack of proper sewage disposal or the contamination of drinking water with sewage. Barwise records an outbreak of typhoid fever at Wesleyan University, Middletown, Conn., in which there is indisputable evidence that it was due to the eating of oysters which had been grown in water contaminated with sewage. He also reports an interesting case of sewage contamination of the water supply at Tees.

Bacillus typhosus is not the only pathogenic germ found in sewage as numerous experiments have shown, that *Bacillus anthracis*, (1) (the Bacteridie du charbon, of the Frénch) not only lives in water but that it maintains its vitality for some time is well know. The spirillum of Asiatic cholera has been known to retain its vitality in the domestic water supply of Berlin from 267 to 382 days. (15). The *Bacillus coli-communis* and *Bacillus cloaceæ* while strictly speaking are not pathogenic are always to be regarded with suspicion when they occur in water as they frequently do. (5). Many disease germs may live in sewage for a short time and be propagated there. Thus it can be readily seen that polluted water is a possible source for almost any bacteriological disease.

It is a fact of common observation that sewage pollution of streams is detrimental to the fish it contains, and indeed cases are recorded where the entire fish life of a stream for a given distance has been destroyed by sewage pollution. A case of this kind happened in our own state a few years ago at Marshalltown.

If no diseases were produced by unpurified sewage, the stench arising from it would be sufficient reason for urging its purification. In this connection it may be well to state that Dr. L. P. Kinnicutt, (15) of Polytechnic, Boston, in a paper, "Sewer Air and Mistaken Ideas Regarding It," maintains with a considerable force of reason that it is not as harmful as commonly believed, but even this does not do away with the fact that it is decidedly disagreeable.

Now that we have noticed some of the reasons for sewage purification it may be well to investigate some of the various means by which it may be accomplished. In a short paper it is impossible to go into details of all the various systems or indeed to even consider them all. So this paper will be confined to the treatment of the following systems: Natural dilution, sewage farming, chemical precipitation, filtration both continuous and intermittent, the septic tank, and the combination of several of these systems into combined systems.

The natural dilution of sewage can hardly be called a system, and yet it is the only means employed in the vast majority of cases. It is nothing more or less than the allowing of sewage to flow into the natural waterways, seas, etc. In this way the concentrated sewage becomes diluted (hence the derivation of the name applied) and nature does the rest. If it were not for the fact that the majority of towns and cities draw their water supply from the rivers on which they are situated, in some few cases it might do very well. A great many factors must be considered in determining the effectiveness of natural dilution, among which the most important are the rapidity of the stream and the volume of water that it carries. As all the rivers in Iowa are relatively small and unimportant this method cannot be considered as sufficient in itself in this state.

The system of sewage farming has been employed quite extensively in various places, but is not commonly considered as a success. The method employed is similar to that used in irrigation. The sewage is allowed to flow through a system of trenches provided with flood gates so that the flow can be controlled. The theory is, and it is correct, that the

plants of the fields to which this is applied will, finally incorporate it intô their own tissues after it has been decomposed by bacteria. As can be readily seen such a system must have several serious disadvantages. First, granting that sewage farming will purify the sewage, which no doubt can be done to a greater or less extent owing to the imposed conditions it is still doubtful whether or not it could be carried on successfully in a great majority of cases. In the first place the land must be of such a character as to permit of the irrigation system; secondly, if the sewage were applied continuously, it would be disastrous to the crops, killing them out as well as preventing the nitrification of the sewage by limiting the supply of oxygen to the soil. In the third place, the amount of desirable land required would in many cases be very expensive if it could be obtained at all. Mr. B. S. Brundell, M. Inst. C. E., who has constructed many sewer farms, among them a farm at Dorchester, England, which is one of the most successful from a sanitary point of view, wrote as follows: "Sewage if properly applied to land may be purified, but the operation is not profitable. That is to say, sewage farming cannot, save in exceptional instances, be made to pay." Mr. Brundell also brings up the additional factor of cold winter weather and seriously doubts whether or not the system could be successfully used in cold countries on account of the protracted cold winter. A very good short account of the Berlin, Germany, sewage farm is given by Barwise.

Chemical precipitation was an effort made on the part of some to entirely purify sewage by the addition of chemicals. The principal precipitants used are lime, iron, aluminum hydrate, alum, and copperas. Although the chemicals used for this purpose are almost innumerable, results tend to show that only the solid matter in suspension is removed, while the sewage is deodorized for the time being. Extensive experiments with chemical precipitation of sewage were made by Mr. Bibden in England well as by the Massachusetts State Board of Health in erica under the supervision and charge of Allen Hazen. cost of constructing a plant for the chemical precipi-

tation of sewage is considerable, besides there is left on hand a sludge which must be disposed of. This would not be a serious drawback if it were valuable as a fertilizer, but chemical analysis seem to show the contrary to be true. On the whole, chemical precipitation is not regarded with favor by the majority of experts.

Filtration is the application of raw or precipitated sewage to beds composed of various substances, either continuously or intermittently. In 1870 the first report of the royal commission on the best means of preventing the pollution of rivers was made. In regard to the filtration method it contained the following:

"The process of filtration through sand, chalk, or certain kinds of soil, if properly carried out, is the most effective means for the purification of sewage. In continuous filtration the sewage is applied to the beds indefinitely without giving them time to rest. This was found to be unsuccessful so a system of allowing the beds to rest at stated periods was tried and found to be highly successful. This latter method is known as the intermittent filtration of sewage. This system of filtration recognizes the fact that the active agents in the purification of sewage are minute plants; variously named microbes, micro-organisms, germs, bacteria, etc. Bacteria is the name now commonly accepted and used in scientific writings and discussions.

Certain species of bacteria have the power of breaking up the complex organic compound of sewage into simpler inorganic harmless compounds. This process is commonly spoken of as nitrification and the bacteria as nitrifying organisms, because the chief inorganic substances formed them are nitrites and nitrates. There are other species of bacteria however that decompose organic materials into various gases, hydrogen (H), carbon dioxide (CO_2), marsh gas (CH_4), nitrogen (N), ammonia (NH_3), etc. Gas-producing bacteria will be spoken of again in connection with the septic tank.

Filter beds, as those used for filtration of sewage are called, are composed of various materials: sand, gravel,

coke breeze, chalk, clinkers, clay, cinders, ballast, etc. Experiments with different materials have been tried at various places. The Massachusetts State Board of Health has probably done the most work along this line in America.

Dibden and Thudicum of England, however, are the pioneers in this line of investigation. There is no small amount of discussion as to the relative merits of the various substances used as fillers in filter beds. But no matter what the material, the object to be obtained in all cases is the same, namely, a substance that will serve as a resting place for the gelatinous masses of bacteria. Any substance that will do this and still be porous enough to admit of complete aeration may be termed a successful filler.

For plans of beds, materials used, dimensions, etc., no better information can be obtained than that in the Massachusetts State Board of Health reports, and for the plans and specifications of the Iowa State College Sewage Plant by Prof. Marston (19).

There remains yet the septic tank. It is a tank in which the sewage is retained for a limited time in order to allow the anaerobic bacteria to work. Two kinds have been employed, the open and the closed. Most experimenters along these lines are now of the opinion that one is as effective as the other, on account of the scum (composed essentially of bacteria) that covers the sewage in the tank. According to L. P. Kinnicutt (16) the following changes are due to anaerobic bacteria in a septic tank. First, the decomposition of cellulose and allied substances, and the formation of marsh gas. Second, the decomposition of complex nitrogenous organic matter, with the production of ammonia, hydrogen and odoriferous substances. Third, the removal of oxygen from nitrates with simultaneous oxidation of organic matter.

As has been stated before, the filter bed gives an excellent opportunity for the action of aerobic bacteria, to which, according to Kinnicutt, the following changes are due: The conversion of urea, and similar substances into ammonium salts, and the conversion of ammonium salts

into nitrates. This being the case the question at once arises, why would not the system of intermittent filtration and of the septic tank work well together. Experience has taught that they do and it is to a system of this kind that the remainder of this paper will be devoted, taking as a basis the sewage system of the Iowa State College. Great credit is due Prof. Marston, who introduced this system in Iowa.

TABULATED BACTERIOLOGICAL RESULTS.

DATE	From.	Temperature. Air.	Temperature. Water.	Manhole	Tank.	Effluent.	
September 1	W. E					2,400	
September 2	E. E					4,800	
September 3	W. E					880	
September 4	E. E					1,320	
September 5	W. E					600	
September 5	Manhole			9,000,000			
September 5	Tank				1,800.000		
September 6	E. E					1,920	
September 7	W. E					1,840	
September 8	W. E					1,560	
September 9	E. E					1,420	
September 10	W. E					3,800	
September 11	W. E					3,640	
September 12	E. E					2,160	
September 12	Manhole			8,600 000			
September 12	Tank				2,050.000		
September 13	E. E					2,400	
September 14	W. E					3,600	
September 15	E. E					2,760	
September 16	W. E					3,960	
September 17	W, E					3,780	
September 18	W. E					2,920	
September 19	W. E					4,080	
September 19	Manhole			7,260,000			
September 19	Tank				2,170. 00		
September 20	W. E					3,660	
September 21	W. E					2,520	
September 22	W. E					2,760	
September 23	W. E					5,400	
September 24	W. E					9,000	
September 25	W. E					9,120	
September 26	W. E					8,040	
September 27	E. E					8,160	
September 27	Manhole			9,600,000			
September 27	Tank				6,960,000		
September 28	E. E					4,400	
September 29	E. E					4,100	
September 30	E. E			8,815,000	3,245,000	3,800	3,660
October 1	E. E					3,760	
October 2	E. E					3,720	
October 3	E. E					3,720	
October 3	Manhole			4,800,000			
October 3	Tank				4,200,000		
October 4	E. E					5,160	
October 5	E. E					4,820	
October 6	W. E					5,040	
October 7	W. E					5,880	
October 8	W. E					5,400	
October 9	E. E					6,120	
October 10	W. E					7,280	
October 10	Manhole			6,480,000			
October 10	Tank				4,618,000		
October 11	E. E					4,200	
October 12	E. E					4,080	

BACTERIOLOGICAL RESULTS—CONTINUED.

DATE.	From.	TEMPERATURE. Air.	Water.	Manhole.	Tank.	Effluent.	
October 13	E. E					3,600	
October 14	E. E					5,760	
October 15	E. E					4,820	
October 16	E. E					4,360	
October 17	E. E					3,720	
October 17	Manhole			4,724,000			
October 17	Tank				5,650,000		
October 18	E. E					4,700	
October 19	E. E					2,640	
October 20	No sample						
October 21	No sample.						
October 22	W. E					4,200	
October 23	W. E					3,700	
October 24	W. E					3,820	
October 24	Manhole			6,760,000			
October 24	Tank				5,040,000		
October 25	W. E					4,600	
October 26	E. E					3,240	
October 27	W. E					3,720	
October 28	W. E					3,580	
October 29	E. E					2,040	
October 3	E. E					1,320	
October 31	W. E					2,880	
October 31	Manhole			7,560,000			
October 31	Tank				5,200,000		4,230
				6,064,800	4,941,000		
November 1	E. E					3,600	
November 2	W. E					3,720	
November 3	E. E					2,280	
November 4	W. E					2,280	
November 5	W. E					2,400	
November 6	W. E					2,640	
November 7	W. E					2,040	
November 7	Manhole			6,800,000			
November 7	Tank				4,350,000		
November 8	W. E					2,520	
November 9	W. E					3,180	
November 10	E. E					3,560	
November 11	E. E					2,520	
November 12	E. E					4,360	
November 13	W. E					4,120	
November 14	W. E					4,500	
November 14	Manhole			5,796,000			
November 14	Tank				3,432,000		
November 15	E. E					2,720	
November 16	E. E					2,560	
November 17	E. E					3,520	
November 18	W. E					2,760	
November 19	W. E					3,080	
November 20	E. E					3,240	
November 21	E. E					2,280	
November 22	E. E					1,800	
November 23	E. E					No develm't	
November 24	E. E					2,060	
November 24	Manhole			1,016,000			
November 24	Tank				1,260,000		
November 25	E. E					1,620	
November 26	No effluent.						
November 27	E. E					4,200	
November 28	No effluent						
November 29	No effluent.						
November 30	E. E			4,537,333	3,014,000	3,000	2,261
December 1	No effluent						
December 2	E. E					3,640	
December 3	E. E					920	
December 4	E. E					1,640	
December 5	E. E					1,840	
December 6	E. E					3,880	
December 7	E. E					280	
December 8	Effl'nt frozen						
December 9	Effl'nt frozen						
December 10	E. E					4,000	

BACTERIOLOGICAL RESULTS—CONTINUED.

DATE.	From.	TEMPERATURE. Air.	TEMPERATURE. Water.	Manhole	Tank.	Effluent.	
December 11...	E. E					1,080	
December 11...	Manhole			92,000			
December 11...	Tank				288,000		
December 12...	Effl'nt frozen						
December 13...	W. E					2,120	
December 14...	W. E					7.800	
December 15...	W. E					2,920	
December 16...	W. E					2,160	
December 17...	W. E					360	
December 18...	W. E					600	
December 18...	Manhole			1,087,000			
December 18...	Tank				1,248,000		
December 19...	W. E					2,520	
December 20...	W. E					2,800	
December 21...	W. E					680	
December 22...	W. E					3,440	
December 23...	W. E					3,720	
December 24...	W. E					3,240	
December 25...	W. E					2,960	
December 25...	Manhole			1,270,000			
December 25...	Tank				1,008,000		
December 26...	W. E					3,120	
December 27...	W. E					2,740	
December 28...	W. E					2,560	
December 29...	W. E					2,120	
December 30...	W. E					1,200	
December 31...	W. E			816,333	848,000	600	2,319
1900.							
January 1	W. E					720	
January 1	Manhole			848,000			
January 1	Tank				726,000		
January 2	W. E					800	
January 3	W. E					920	
January 4	W. E			848,000	726,000	1,000	830
February 1	W. E			363,700		7,272	
February 1	Manhole				287,900		
February 1	Tank						
February 2	W. E					1.800	
February 3	W. E					1.280	3 451
February 9	Manhole			651,200			
February 9	Tank				509,000		
February 15	Manhole			20,600			
February 15	Tank				12.240		
February 22	Manhole			468,700			
February 22	Tank				419,200		
February 25	Manhole			132,400			
February 25	Tank				108.000		
February 29	Manhole			No devel.			
February 29	Tank				66,520		3 451
				345,533	233,810		
March 6	Manhole			80,600			
March 6	Tank				No devel.		
March 10	Manhole			184,600			
March 10	Tank				98,700		
March 11	W. E					23,400	
March 12	W. E					39,000	
March 13	W. E					21,000	
March 14	W. E					12,000	
March 14	Manhole			204,500			
March 14	Tank				126,300		
March 15	W. E					36,000	
March 18	Manhole			58,800			26,480
				132,125	112,500		
April 1	W. E					16,800	
April 2	W. E					15,000	
April 3	W. E					15,600	
April 4	W. E					12,600	
April 5	W. E					6,000	
April 6	W. E					13,400	
April 7	W. E					14,400	
April 8	W. E					13,200	
April 9	W. E					21,000	
April 10	W. E					24,000	

BACTERIOLOGICAL RESULTS — CONTINUED.

DATE.	From.	TEMPERATURE. Air.	TEMPERATURE. Water.	Manhole.	Tank.	Effluent.	
April 11	W. E					17,000	
April 12	W. E					15,600	
April 12	Manhole			3,151,200			
April 12	Tank				1,999,800		
April 13	W. E					24,000	
April 14	W. E					16,800	
April 15	W. E					18,600	
April 16	W. E					19,200	
April 17	W. E					18,000	
April 18	W. E					17,500	
April 19	E. E					7,200	
April 20	E. E					4,800	
April 21	E. E					30,000	
April 22	E. E					14,400	
April 23	E. E					12,000	
April 24	W. E					6,000	
April 25	E. E					5,400	
April 25	Manhole			1,090,800			
April 25	Tank				787,800		
April 26	W. E		61 degrees			7,200	
April 27	W. E		64 degrees			4 8 0	
April 28	W. E		63 degrees			6,600	
April 29	W. E		59 degrees			4,200	
April 30	W. E		63 degrees			5,400	13,260
				2,121,000	1,392,800		
May 1	W. E		63 degrees			3,600	
May 2	W. E		64 degrees			4,200	
May 2	Manhole			666,600			
May 2	Tank				242,000		
May 3	W. E		62 degrees			1,500	
May 4	W. E		60 degrees			10,200	
May 5	W. E		63 degrees			3,000	
May 6	W. E	73 degrees	61 degrees			2,400	
May 7	W. E	72 degrees	61 degress			1,800	
May 8	E. E	69 degrees	61 degrees			3,600	
May 9	E. E	71 degrees	61 degrees			2,400	
May 10	E. E	76 degrees	63 degrees			210	
May 11	W. E	70 degrees	62 degrees			2,400	
May 12	W. E	72 degrees	63 degrees			1,940	
May 13	W. E	71 degrees	63 degrees			2,000	
May 14	W. E	73 degrees	68 degrees			4,160	
May 15	W. E	56 degrees	68 degrees			4,200	
May 16	E. E	69 degrees	64 degrees			3,600	
May 17	W. E	62 degrees	65 degrees			3,000	
May 18	W. E	50 degrees	63 degrees			9,600	
May 19	W. E	67 degrees	60 degrees			2,700	
May 20	W. E	72 degrees	61 degrees			2,100	
May 21	E. E	78 degrees	62 degrees			1,500	
May 22	W. E	78 degrees	63 degrees			1,200	
May 22	Manhole			900,000			
May 22	Tank				1,800,000		
May 23	W. E	76 degrees	63 degrees			2,100	
May 24	W. E	73 degrees	63 degrees			1,800	
May 25	W. E	77 degrees	64 degrees			2,400	
May 26	W. E	81 degrees	65 degrees			4,200	
May 27	W. E	82 degrees	67 degrees			3,000	
May 28	W. E	76 degrees	68 degrees			3,600	
May 29	W. E	79 degrees	68 degrees			2,400	
May 30	W. E	80 degrees	68 degrees			2,800	
May 31	W. E	81 degrees	69 degrees			1,800	2,077
				1,021,000	783,300		
June 1	E. E	82 degrees	69 degrees			60	
June 2	E. E	81 degrees	69 degrees			1,200	
June 3	E. E	80 degrees	69 degrees			900	
June 4	W. E	73 degrees	69 degrees			1,800	
June 5	W. E	82 degrees	69 degrees			5,400	
June 5	Manhole			1,272,600			
June 5	Tank				1,636,200		
June 6	W. E	81 degrees	69 degrees			150	
June 7	W. E	80 degrees	69 degrees			2,100	
June 8	W. E	79 degrees	69 degrees			1,800	
June 9	W. E	78 degrees	69 degrees			3,000	
June 10	E. E	85 degrees	69 degrees			90	

BACTERIOLOGICAL RESULTS—CONTINUED.

DATE.	From.	TEMPERATURE. Air.	Water.	Manhole.	Tank.	Effluent.	
June 11	E.E.	51 degrees	69 degrees			15,800	
June 12	W.E.	70 degrees	69 degrees			4,000	
June 13	E.E.	74 degrees	67 degrees			3,000	
June 14	W.E.	83 degrees	69 degrees			6,000	
June 15	E.E.	79 degrees	69 degrees			2,400	
June 15	Manhole.			1,545,400			
June 15	Tank				1,324,000		
June 16	E.E	78 degrees	69 degrees			2,400	
June 17	W.E	75 degrees	68 degrees			1,600	
June 18	W.E	73 degrees	68 degrees			3,000	
June 19	W.E.	82 degrees	69 degrees			4,100	
June 19	Manhole.			1,363,600			
June 19	Tank				1,090,000		
June 20	W.E	80 degrees	69 degrees			3,600	
June 21	E.E	76 degrees	69 degrees			2,400	
June 22	E.E	74 degrees	69 degrees			450	
June 23	W.E.	73 degrees	69 degrees			560	
June 24	E.E.	73 degrees	69 degrees			640	
June 25	E.E.	86 degrees	70 degrees			1,200	
June 2[illegible]	W.E.	89 degrees	72 degrees			1,410	
June 26	Manhole		77 degrees	1,090,800			
June 26	Tank		67 degrees		1,515,000		
June 27	E.E	76 degrees	72 degrees			570	
June 28	W.E	81 degrees	72 degrees			160	
June 29	E.E	76 degrees	72 degrees			540	
June 30	E.E	64 degrees	72 degrees	1,318,100	1,391,300	850	2,359
July 1	W.E	70 degrees	72 degrees			780	
July 2	W.E	85 degrees	70 degrees			840	
July 3	W.E.	92 degrees	69 degrees			980	
July 4	W.E.	90 degrees	72 degrees			1,040	
July 5	Outlet flooded						
July 6	Outlet flooded						
July 7	W.E.	84 degrees	76 degrees			15,000	
July 8	W.E.	77 degrees	75 degrees			540	
July 9	E E	82 degrees	76 degrees			1,600	
July 10	Outlet flooded						
July 11	Outlet flooded						
July 12	W.E.	72 degrees	72 degrees			2,400	
July 12	Manhole		68 degrees	363,600	(Gelatine)		
July 12	Manhole		68 degrees	104,030	(Agar†)		
July 12	Manhole		68 degrees	242,400	(Agar)		
July 12	Tank		62 degrees		(Gelatine)		
July 12	Tank			(Agar†)	426,000		
July 12	Tank		62 degrees	(Agar)	342,400		
July 12	Tank		62 degrees	(Agar†)		114,130	
July 12	W.E.	72 degrees	72 degrees	(Agar†)		250	
July 13	E.E	78 degrees	72 degrees			900	
July 14	E.E	82 degrees	72 degrees			370	
July 15	W.E.	84 degrees	74 degrees			6,000	
July 16	W.E.	69 degrees	72 degrees			130	
July 17	E.E	72 degrees	72 degrees			8,040	
July 17	Manhole		67 degrees	7,575,000			
July 17	Tank		67 degrees		9,090,000		
July 18	E.E.	78 degrees	72 degrees			360	
July 19	E.E.	68 degrees	72 degrees			4,800	
July 20	E.E.	73 degrees	71 degrees			4,200	
July 21	E.E.	72 degrees	71 degrees			9,600	
July 22	* Effluent						
July 23	E.E	82 degrees	71 degrees			3,600	
July 23	Manhole		68 degrees	(Too ††)			
July 23	Tank		66 degrees		4,302,600		
July 24	* Effluent						
July 25	* Effluent						
July 26	* Effluent						
July 27	E.E	78 degrees	70 degrees			210	
July 28	W.E.	75 degrees	72 degrees			1,260	
July 29	E.E	78 degrees	72 degrees			90	
July 30	W.E	90 degrees	73 degrees			1,800	
July 31	W.E.	80 degrees	73 degrees	3,908,700	4,578,333	360	2,270
August 1	E.E.	76 degrees	71 degrees			980	
August 1	Manhole		71 degrees	1,346,600			

* Effluent under water. † Agar for gas. †† Too thick to count.

BACTERIOLOGICAL RESULTS—CONTINUED.

DATE.	From.	TEMPERATURE. Air.	TEMPERATURE. Water.	Manhole.	Tank.	Effluent.	
August 1	Tank		64 degrees		672,000		
August 2	W.E.	77 degrees	74 degrees			1,200	
August 3	E.E.	81 degrees	71 degrees			100	
August 4	W.E.	78 degrees	74 degrees			3,600	
August 5	E.E.	88 degrees	75 degrees			70	
August 6	W.E.	84 degrees	75 degrees			60	
August 7	W.E.	85 degrees	76 degrees			400	
August 7	Manhole		71 degrees	87,870			
August 7	Tank		68 degrees		80,800		
August 8	E.E.	82 degrees	76 degrees			300	
August 9	E.E.	83 degrees	75 degrees			400	
August 10	W.E.	88 degrees	76 degrees			20	
August 11	E.E.	87 degrees	76 degrees			120	
August 12	*Effluent						
August 13	*Effluent						
August 14	*Effluent						
August 15	*Effluent						
August 16	*Effluent						
August 17	W.E.	92 degrees	76 degrees			90	
August 17	Manhole		70 degrees	68,000			
August 17	Tank		68 degrees		26,000		
August 18	*Effluent						
August 19	*Effluent						
August 20	*Effluent						
August 21	W.E.	80 degrees	75 degrees			320	
August 22	E.E.	79 degrees	75 degrees			430	
August 22	Manhole			120,000			
August 22	Tank				84,000		
August 23	W.E.	85 degrees	76 degrees			980	
August 24	E.E.	86 degrees	76 degrees			380	
August 25	E.E.	84 degrees	75 degrees			12	
August 26	E.E.	80 degrees	73 degrees			160	
August 27	E.E.	81 degrees	73 degrees			290	
August 28	W.E.	80 degrees	72 degrees			310	
August 29	W.E.	88 degrees	72 degrees			680	
August 30	E.E.	83 degrees	73 degrees			640	
August 31	W.E.	82 degrees	73 degrees	403,118	215,700	360	560

* Effluent under water.

Average number of germs per cubic centimeter, in effluent.

MONTH.	AVERAGE.
1899.	
August	2,246
September	3,660
October	4,230
November	2,261
December	2,319
1900.	
January	830
February	3,451
March	23,480
April	13,263
May	3,077
June	2,359
July	2,270
August	546
September	850

Average number of bacteria per c.c. in manhole and tank.

MONTH	Manhole.	Tank.
August, 1899	2,392,600	1,358.300
September, 1899	8,815,000	3,245,000
October, 1899	6,064,800	4,941,000
November, 1899	4,537.333	3,014,000
December, 1899	816,333	848,000
January, 1900	848.000	726.000
February, 1900	345,533	233,810
March, 1900	132,125	112,500
April, 1900	2,121,000	1,392,800
May, 1900	1,021,000	783,300
June, 1900	1,318,100	1,391.300
July, 1900	3,908,700	4,578,333
August, 1900	403,118	215,700
September, 1900	1,181.533	383,733

BACTERIOLOGICAL ANALYSIS OF THE COLLEGE SEWAGE FROM SEPT. 1, 1899, TO SEPT. 1, 1900.

The college sewage system is a combination of several systems combined into one. It combines the system of the septic tank with that of intermittent filtration. For a very excellent and (20) detailed description, see the article in Centralblatt No. 15, on the Iowa State College Sewage Disposal Plant, by Drs. Pammel, Weems, and Professor Marston, and Contribution No. 1 of the Iowa State College (19).

Bacteriological analysis have been made of the effluent each day, while once each week samples have been taken from the manhole and the tank, as well as the effluent, of which both bacterological and chemical analyses have been made. The chemical analyses have been under the direction of Dr. Weems, who has from time to time published some very interesting results, but as it is my intention to deal with the bacteriological side only, no chemical results will be given, only as they may serve to elucidate some point in connection with the bacteriological analyses.

In making the cultures, petri dishes of a standard size have been used. The dilution method has been employed with the manhole and tank samples, it having been found on trial that without dilution it was practically impossible

to count the number of colonies. For this dilution one-tenth of a cubic centimeter of sewage is put into ten cubic centimeters of sterilized water, and one-tenth c.c. of this taken to make the culture. With the effluent no dilution has been made. Two methods of counting the plates have been employed. One is to divide the plates by means of a dividing circle into twenty equal divisions, counting three of these divisions, dividing by three to strike an average, and multiplying by twenty the number of divisions on the plate, and by ten, the denominator of the fractional part of a c.c. of sewage taken to make the culture. Of course, when dilutions were made the above result was multiplied by the denominator of the fractional part of a c.c. used, as to illustrate, 21+18+12=51÷3=17X20=340X10=3,400X101=343,400. The above sample being diluted by ten c.c. of sterilized water to 1-10 of a c.c. of sewage.

The other method is practically the same. The plate is divided into sixty square centimeters; three square centimeters are averaged and multiplied by the number of square c.c. in the plate and the fraction of the denominator of the dilution.

In each method care was taken to obtain a good average of the plate. As an illustration, if there was a spot where the colonies were especially thick or thin, counts were taken from them, and also from a spot containing about an average number of bacteria, if possible.

The pipettes, petri dishes, etc., used in the work, were sterilized by dry heat for one hour and kept away from dust and moisture.

The media used in these experiments has been, in the main, ordinary agar agar, gelatine having been used on several occasions to determine the variations between the number of colonies produced by agar and gelatine cultures respectively. It was found that on gelatine plates there is usually a slight increase in the number of colonies, but on account of the liquefying properties, it has not given as much satisfaction as agar cultures.

Another method employed for the determination of gas producers is of special interest, as it can be shown by

making parallel cultures the relative number of gas producers present in a c.c. of sewage.

A method which has given excellent results is as follows: Take a tube of ordinary agar, melt and pour in a petri dish, after it has cooled to such a degree that it is just liquid, add one-tenth cc. of sewage and immediately turn it around rapidly in order to secure equal distribution of the sewage; then, after it has been cooled so far as to become solid, add another tube of melted agar, care being taken that it is not too hot, after which, without stirring, set it away to develop. This last agar forms a layer containing no germs, if the work has been properly done. The anærobic gas producers working in the lower portion produce gas, which appears in the agar as minute air bubbles.

The effluent of July 12, 1900, after standing one week, showed 25 gas producers in the plate, and as one-tenth c.c. of sewage from the effluent was used in making the culture, there would be 250 gas producers to the c.c. of effluent. The number of germs counted from a parallel culture was 2,400, which means that approximately ten per cent of the total number of germs were gas producers, the above result being obtained from the sample of effluent taken from the west bed. The temperature of the air and sewage being 72° Fahrenheit. A similar culture from the tank on the same date showed 113 gas producers in the plate, making 114, 130 gas producers to the c.c. of sewage, or about 33⅓ per cent of the germs in the tank at that time were gas producers, the temperature of the sewage in the tank being 62°. The total number of germs for the c.c. being 342,400.

The manhole sample taken July 12th and examined July 17th, shows a still greater percentage, there being 104,030 gas producers to the c.c., or 43 per cent of the germs in the raw sewage at that time were gas producers. The temperature of the raw sewage was 68°, the total number of germs to the c.c. on an ager culture being 242,400. Other cultures were made in the same manner, with approximately the same results.

It will be noticed that the percentage of gas producers is highest in the manhole, and lowest in the effluent, while the number in the tank lies between, which would seem to show that the gas producers are destroyed while the sewage is passing through the tank and filter bed, which is very desiraable, in view of the fact that gas producing species, while not actually condemned as pathogenic, are to be regarded with suspicion.

The primary object of bacteriological analysis of sewage is to determine the number of germs present per c.c. in the sewage at the different stages of its purification. By such data the efficiency of the beds and other parts of the system may be readily determined.

The number of germs present per c.c. determine the relative purity of the water, but far more important from a sanitary standpoint, is the kind of germs present.

But little attention has been given to the determination of species, except incidentally. *Bacillus cloacea*, *B. coli-communis*, and some others were determined by Dr. Pammel and O. J. Fay, while I have run out *B. prodigiosus*, *B. mutabalis*, and several other species.

Bacillus prodigiosus does not occur in the sewage to any considerable extent, it having been found up to date only three times; once in the tank on June 19th, and twice in the effluent, once on the 22nd of June in the east effluent, and once on the 27th of June in the west effluent. At no time was more than one colony found on the plates in any of the above cultures. Its appearance at that time is both significant and interesting; significant in showing the efficiency of the beds but two colonies having been found one coming from each bed, at an interval of five days from each other. which would seem to indicate that the germs were present in very small quantities and that the beds are about equal from the standpoint of efficiency.

It is interesting from the fact that it presumably found its way into the sewage by washing petri dishes continually in a sink in the laboratory which empties into the sewer. The original culture having been obtained at Marshalltown about the middle of March, 1900. This one

example gives sufficient evidence of the possibility of the transmission of disease germs by means of water, and especially sewage.

One question which presents itself on the accompanying data is the wide degree of fluctuation in the number of germs per c.c. found in the effluent.

Take for example the results from June 1, 1900 to June 15th, inclusive. The number of bacteria to the c.c. ranged from sixty on June 1st to 15,800 on June 15th. Why this difference? After considerable research and observation it seems that at least three factors would largely determine the number of bacteria to the c.c. present at any particular time. Perhaps of primary importance is the temperature of the sewage and thus indirectly of the soil through which it is filtered, and the air. It is a well recognized fact that the warmer the sewage up to a certain point the faster the division of bacteria takes place, hence a larger number of germs would be found in warm sewage and during warm weather. Take the result for June 1, 1900 the air was 82 degrees Fahrenheit, the sewage 69 degrees and the number of germs per c.c. is 60. The following day, June 2nd, the air is one degree cooler and the water the same temperature, yet there are 1,200 bacteria to the c.c. Take from the first of June to the 11th and although the temperature of the sewage is constant the number of germs per c.c. fluctuates from 60 to 15,800. The soil temperature for June 11th was 69 degrees. As the soil temperatures have been taken but once a week it is impossible to give its variations in temperature from day to day.

Second, the condition of the sewage to be purified will determine to a very great degree the number of bacteria to the c.c. but by comparison of the data it will be seen that this does not offer a satisfactory explanation in itself. Take for instance the results for November 14, 1899 as compared with those of June 19, 1900. While the number of bacteria to the c.c. in the effluent varies only by 400 (November 14, 1899, 4,500. June 19, 1900, 4,100) the number of germs in the raw sewage varies some five and one-

third millions to the c.c. If this were the principal cause of fluctuation the effluent of November 14th should contain about 41,000 bacteria to the c.c. other things being equal.

Along with the above the amount of organic matter present would have a considerable influence, as it would serve as food for the bacteria. Hence fission would be more rapid and the number of bacteria to the c.c. increased, but no data bearing on this point are at hand.

The third factor would be the time of taking the samples, whether at the beginning or toward the end of the discharge. It is presumed that during the period that the bed is resting the bacterial life increases; accumulating in the interstices between the material of which the filter is composed. When the discharge comes on the beds the pressure and hence the force being greater at that time than at any other, also the number of the bacteria in the interstices being greatest then, might not the force of the sewage wash these bacteria free and hence through the bed into the effluent? If such be the case the number of bacteria to a c.c. would be greatest at the beginning of the discharge and least at the end. While I have not been able to make experiments to fully elucidate this point I feel quite confident from numerous observations in taking samples that such may be the case.

Of course all of these factors and probably others acting in unison complicate the problem to such an extent that until more data is at hand it will be impossible to accurately determine the exact amount of variation caused by each factor.

By referring to the tables containing the average number of germs per c.c. for each month, of manhole, tank, and effluent, it will be observed that there is considerable fluctuation. It will also be noticed that the results for the manhole, tank, and effluent decrease on the whole together. The month containing the lowest average for the effluent is August in 1900 as well as 1899. The largest average for the effluent in 1900 is March after which there is a gradual decrease until September. Several things must be taken

into account in considering the cause of these fluctuations. One is that during March and April there are greater fluctuations in temperature, as well as in the humidity of the atmosphere and it is possible that such a condition might favor the rapid multiplication of bacteria. Again, in July and August and the major part of June, college was not in session, hence the sewage was not so strong. In a general way it would appear that the factors considered in connection with the fluctuations of the effluent are applicable here also.

One point which is rather interesting is that on different occasions, (June, July, 1900, also December of the same year), the average number of germs to the c.c. in the tank was larger than that of the manhole for the same period. The explanation of this seeming inconsistency seems simple enough after taking into consideration the fact that bacteria increase very rapidly, and that the sewage is allowed to collect in the tank until 20,000 gallons have been accumulated, when it is discharged automatically by a Miller's Automatic Siphon. Now, if the flow in the tank is slow (which is often the case) for any reason, the water stands longer, and hence more time is given the bacteria to multiply.

It must be borne in mind that the environment in the tank is especially favorable for the rapid production of bacteria as there is an abundance of organic matter present, while the tank being closed would tend to raise the temperature of the sewage rather than to lower it, which would further facilitate the rapid development of germ life. Leone's experiments on the preserving of the Mangfall water shows very clearly what might be expected from letting sewage accumulate slowly in the tank. It takes some times seventeen to twenty hours and even longer for the tank to fill. Below are given the tabulated results of his experiments together with some similar observations made by Cramer on the water from the Lake of Zurich.

LEONE'S OBSERVATIONS.

	No. of Micro-organisms in one CC. of water.
Water at time of collection contained	5
Water after standing twenty-four hours in sterilized flask	100
Water after standing two days in sterilized flask	10,500
Water after standing three days in sterilized flask	67,000
Water after standing four days in sterilized flask	315,000
Water after standing five days in sterilized flask	More than one-half million

CRAMER'S OBSERVATIONS.

Hours and days during which the water was preserved.	Number of Micro-organisms in one CC. of water.
0 hours	143
24 hours	12,457
3 days	328,543
8 days	233,452
17 days	17,436
70 days	2,500

The work along these lines on the college sewage may be said to have just begun, and future experiments and data will materially assist in the intelligent interpretation of the results obtained during the last year.

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NOTES ON THE BACTERIOLOGICAL ANALYSIS OF WATER.

BY L. H. PAMMEL.

The recent epidemic of typhoid fever at the college is of interest to us and especially the methods now in vogue with reference to the examination of water for various organisms. During the recent epidemic and previously the well waters in the vicinity of Ames as well as the college water supply were examined at various times. An examination has also been made of water coming from wells of the parties who have furnished milk to the college. It should be stated here that this report is not completed owing to the fact that some of the species have not been sufficiently determined. From the nature of the case it requires a great deal of patient and careful work to run out the different species, so that the biological examination was not completed. Thanks are due to Mr. F. W. Faurot, Mr. A. D. McKinley, Mr. H. H. Thomas, Miss Nellie Nicholas, Miss Estella Paddock, and Mr. L. R. Walker for assistance in carrying out this work.

In the paper on the Iowa State College Sewage Disposal Plant will be found a brief note on the water of the deep well previous to this spring. Examinations have been made from time to time, and as a result of our work, we found that the water during the winter months varied from no bacteria to 50 per cubic centimeter, thus showing an unusually good supply of water.

A Marston, J. B. Weems and L. H. Pammel. The Iowa State College Sewage Disposal Plant and Investigations. Proc. Ia. Engineering Soc. 1900. Contr. Ia. State Coll. Argrl. & Mech. Arts. 1:19.

BRILEY SHALLOW WELL.

Depth, 45 feet; 18-inch glazed tile, cemented at the joints, covered with boards on top. The well has not been used since October 20th.

DATE.	GAS TEST.	Total number bacteria per CC.	GELATINE. Liquefying.	GELATINE. Non-liquefying.	Agar.	LITMUS AGAR.
October 17th......	Present	18,000	....	....	Used.	Some acid-producing germs.
October 18th......	....	12,000	......	.....	Used.	
October 25th ..	First pumping........ ...	6,000	.....	......	Used.	
October 25th	One-half barrel pumped....	1,440	....	......	Used.	
October 25th	One barrel pumped	2,000	......	.....	Used.	
October 25th	1½ barrel pumped	2,400	..	......	Used.	
October 29th	Present	125		125		

BRILEY DEEP WELL.

Depth, 185 feet; 2-inch pipe and casing.

October 17th	....	60	......	....	Used.	No acid-producing germs.
October 17th	None	...	30			
October 18th	None	30				
October 27th	....	30	......		Used	
October 29th	. ...	30				

PRITCHARD WELL AND TANK—WELL.

Depth, 170 feet; 3-inch casing well and inside a 2-inch pipe.

October 18th	....	20				
October 22d..... .	....	30	.... .	30	Used.	
October 29th......	....	20	.... .	20	..... .	Non-acid-producing.
October 18th	.....	60	20	40		

TANK.

Open tank used for watering stock, above well.

October 29th......	....	40				
October 29th......	3½ cc......................	160				
October 31st......	....	225	....	....	225	
October 29th......	3½ cc	....	....	....	......	Acid reaction.

PETERSON WELL AND TANK.—WELL.

Depth, 185 feet; 120 feet down to cylinder. Cased. Two inch iron, with about four inch of casing. Located two miles north of Ontario.

Date.	Gas test.	Total number bacteria per cc.	Gelatine. Liquefying.	Gelatine. Non-liquefying.	Agar.	Litmus agar.
October 27th	7 cc					
October 18th		150			150	
October 18th		170				
October 18th		1,500			1,500	
October 27th		3,360	3,360			
October 29th		9,000	1,800	7,200		
Octaber 18th		80				80 Non-acid.

TANK.

Open tank for watering stock.

Date.	Gas test.	Total number bacteria per cc.	Gelatine. Liquefying.	Gelatine. Non-liquefying.	Agar.	Litmus agar.
October 18th	3 cc	25			25	Acid producing
October 29th	Acid	2,600	360	2,240		
October 31st	10 molds	4,200			4,200	100 acid.
October 18th					320	220 non acid.

SKELTON WELL.

Thirty-five feet deep, ten inch casing.

Date.	Gas test.	Total number bacteria per cc.	Gelatine. Liquefying.	Gelatine. Non-liquefying.	Agar.	Litmus agar.
October 18th		30			30	Non-acid.
October 18th		10				
October 27th	3 cc					Acid.
October 31st		200			200	
October 27th	2 molds	90				
October 27th	No. 2	633			633	

RIVER WATER.

Date.	Skunk River Water. Total number germs per cc.	Skunk River Water. Medium used agar.	Date	Squaw Creek Water. Total number germs per cc.	Squaw Creek Water. Medium used agar.
April 30th	1,800		May 19th	300	
May 7th	1,800		July 2nd	11,200	
May 9th	916		August 8th	16,200	
May 19th	1,800		August 8th	8,520	
July 6th	27,000		October 4th	2,400	

Investigations carried on with the water supply of various wells in the vicinity of Ames by Messrs. McKinley and Thomas and Mr. Faurot gave the following results:

FAUROT'S WELL.

DATE.	Number germs per cc.	REMARKS.
April 23d..........	1,600	
April 23d..........	4,500	
May 22d..........	9,360	
May 29th..........	9,480	
July 6th..........	220	Collected after a rain
Average.....	5,032	

OTIS HOUSE WELL.

May 7th..........	80	Collected without ice.
May 21st..........	3	Collected without ice.
May 28th..........	200	Collected without ice.
July 2d..........	54,000	Indication of something in pipes.
August 8th........	120	Indication of something in pipes.
August 8th........	None	After pumping 15 minutes, collected with ice.
October 4th.......	120	With ice—first pumping.
October 4th.......	360	With ice—after pumping.
October 23d.......	3,000	First pumping—no gas.
October 23d.......	2,400	Second pumping—no gas.
Average.....	6,028	

LABORATORY TAP.

May 7th..........	None.	Poured immediately.
May 21st..........	None.	Poured immediately.
October 4th.......	360	Poured immediately.
October 17th......	520	Poured immediately.
October 17th......	700	Poured immediately.
November 6th.....	80	Poured immediately.
Average.....	276	

PARSON'S WELL.

May 7th..........	3,600	Well full.
May 21st..........	Failure.	Well full.
May 28th..........	1,300	Well full.
July 2nd..........	90	With ice. First pumping. Very little water in well.
August 8th.........	150	With ice. First pumping. Very little water in well.
August 8th.........	170	With ice. Second pumping. Very little water in well.
October 23d.......	50	Without ice. Second pumping. No gas.
October 23d.......	380	Without ice. First pumping.
Average.	643	

ILLSLEY'S WELL.

DATE.	Number germs per cc.	REMARKS.
May 7th	8,000	
May 21st	Failure.	
May 28th	600	
July 2d	1,200	
August 8th	590	Without ice. First pumping.
August 8th	220	With ice. Second pumping.
October 23d.	80	No gas. Second pumping.
October 23d......	800	First pumping.
Average	1,642	

WELL AT HOUSE NEAR BRICK YARD.

May 21st	300	
July 2d	330	
August 8th	10,800	First pumping.
August 8th	7,800	With ice. Second pumping.
October 4th.......	1,400	With ice. First pumping.
October 4th.....	5,400	With ice. Second pumping.
Average ...	4,338	

CREEK WATER.

May 19th	300	
July 2d..........	11,200	
August 8th.......	16,200	Without ice.
August 8th	8,520	With ice.
October 4th..	2,4co	With ice,
Average	7,724	

OLSEN'S WELL.

May 28th	10	
August 8th.......	60	With ice. Wind mill in operation one-half day.
August 8th	350	Wind mill in operation one-half day.
October 4th	600	With ice. First pumping.
October 4th	120	With ice. Second pumping.
October 23th	620	Without ice. First pumping.
October 23th.....	240	Without ice. Second pumping. No gas.
Average .	286	

FOUNTAIN WATER IN PARK, STORY CITY, IOWA.

October 7th.......	4,500	Without ice. Poured in laboratory. No gas.
October 13th......	20	Poured immediately.

HIGH SCHOOL, STORY CITY, IOWA.

October 7th.......	400	Collected without ice. No gas.
October 13th......	440	Poured at well.

HENRYSON'S WELL, STORY CITY, IOWA.

DATE.	Number germs per cc.	REMARKS.
October 7th.......	280	Collected without ice Produced gas.
October 13th......	230	Poured at well.

HYDRANT, STORY CITY, IOWA.

October 7th.......	520	Without ice. No gas.
October 13th......	30	Poured at hydrant.

C. & N. W. WELL AT WEBSTER CITY, IOWA.

October 6th.......	310	Without ice. Gas.

A. J. HAVILAND'S WELL, FORT DODGE, IOWA.

October 5th.......	150	Without ice. 30 moulds.

WILL HAVILAND'S WELL, FORT DODGE, IOWA.

October 5th.......	5,400	Without ice.

The records kept by Miss Nicholas were as follows:

MUNN'S WELL.

May 5th	570	Agar used.
September 24th....	300	Agar used.
October 11th.......	80	Agar used.

PAMMEL'S WELL.

September 9th.....	1,300	Agar used.
August 11th.	400	Agar used.
September 27th....	510	Agar used.

BUDD'S WELL.

May 5th...........	50	Agar used.
September 27th....	40	Agar used.
October 8th........	30	Agar used.
October 27th.......	20	Litmus agar used. Non-acid producing.

REED'S WELL.

DATE.	Number germs per cc.	REMARKS.
May 17th	2,500	Agar used.
May 31st	1,200	Agar used.
September 19th	700	Agar used.
October 27th	....	Litmus agar used. Acid and non-acid.

MILLER'S WELL.

May 17th	270	Agar used.
May 31st	400	Agar used.

PAXTON'S WELL.

May 17th	1,900	Agar used.
September 19th	1,300	Agar used.
September 27th	2,400	Agar used.

HARDIN'S WELL.

May 31st	30	Agar used.

LINCOLN'S WELL.

May 5th	300	Agar used. } No gas at any time.
May 31st	400	Agar used. } No gas at any time.
September 27th	100	Agar used. } No gas at any time.

HUNT'S CISTERN.

May 17th	150	Agar used.

HOOVER'S SPRING.

May 17th	2,400	Agar used.
October 27th	40	Litmus agar used. Non acid producing.

The following are the results of Miss Nicholas of examination of samples, the second after discarding a few pailsfull. The medium used was ordinary agar.

DATE.	Well.	First pumping.	Second pumping.
September 9th	Lincoln	460	330
September 9th	Munn	240	230
October 8th	Budd	30	20
October 8th	Lincoln	180	170
October 8th	Reed	1,700	1,600
	Kinkade	2,800	6,000

The Kinkade well is very shallow and the second sample was collected after several barrels of water had been pumped out, therefore the much greater number of bacteria in the second sample may be due to sediment.

All of the shallow wells examined contained gas-producing germs. The Paxton well produced 30 cc. of gas in the fermentation tube, 10 cc. of which was CO_2 and 20 cc. CH_4. The Reed well produced 100 cc. of gas (40 cc. CO_2 and 60 cc. CH_4). The water from the Kinkade well produced a very great amount of gas.

The Briley Shallow Well.—In conjunction with Dr. Weems and Mr. McKinley on another occasion the writer collected samples of the water at the Briley well, and later Mr. Faurot also collected this water twice. The second time when Mr. Faurot collected these samples we got an unusually large number of germs per cubic centimeter. That collected by the writer on October 17 had 18,000 and that by Mr. Faurot had 6,000. It is worthy of note in this connection that the samples collected by myself on October 17 contained 18,000 germs per cc., that in one of the samples collected by Mr. Faurot on October 25, the number of germs had diminished very materially, the largest number found was 6,000. On October 29 the highest number obtained was 125 per cc.

In regard to the last plates poured it is a singular fact that but a very small development occurred, and this is strange since we had such an unusual development before running from 6,000 to 18,000 per cubic centimeter.

In regard to the condition of the well it looks as though the water could easily have drained off from the surface, but nevertheless upon removing some of the boards from the top of the well I found that the water might easily have entered between the cracks of some of the boards. In fact I found moisture on the inside on the upper tile, showing the water had run down. One can readily see how *B. coli-communis* or other foreign organisms could get into the water. Gas was produced in one tube poured by Mr. Faurot and a slight amount in another. In this case we made the usual test. We also obtained gas from the first plates that I poured.

The samples collected on October 29 were kept for forty days in the laboratory and then were examined by Mr. McKinley and Mr. Thomas with the following results:

WELL.	Depth.	No. of germs.
Briley Shallow Well	45 feet.	200
Briley Deep Well	185 feet.	20
Laboratory tap. Same source	....	10
Kitchen Tap	....	None.
Skelton's Well	35 feet.	30
Peterson Deep Well	185 feet.	340
Peterson's Trough	....	1.000
Pritchard Well	170 feet.	30

Various species were found. Some of these have been excluded as having no connection with *Bacillus typhosus* or *B. coli-communis*. On the other hand there are a number of species that belong to the typhosus group culturally so far as has been carried out. Our work was interrupted although cultures of all of the species were made and placed away for further study. Fire destroyed the entire laboratory so no further study can be made.

One peculiar pearly white Bacillus developed in considerable quantity, in fact at least three-fourths of the colon-

ies belonged to this species. This Bacillus though actively motile had none of the cultural peculiarities of *B. typhosus.* Two species are quite commonly found in surface waters, namely the *B. cloacæ* first detected by Jordan in sewage.

I am inclined to think that both *B. coli-communis* and *B. cloacæ* occurred in the Briley shallow well, but the definite separation was not carried far enough to determine this point to my satisfaction, though Dr. Eli Grimes states *B. coli-communis* was found.

THE COLLEGE WATER SUPPLY.

It is certainly worthy of mention in this connection that all of the species found in the college water supply in the tank are non-liquefying, and the fact that gas was found on one occasion does not argue that the college water supply was contaminated. The simple fact that the species here found did not produce gas in the proportion given for *B. coli-communis,* namely, of two parts of H. to one part of CO_2, but represented by formula one to two. It is also a significant fact that morphologically none of the species found indicated either *B. coli-communis* or *B. typhosus* in the college water supply.

Of the oft-repeated statement that sewage contamination might have occurred, I wish to state that the writer, together with Professor Marston, climbed to the top of the tower and investigated conditions, and everything was found in its usual good condition. There was certainly no indication of growth of algæ on the water, nor were there any indications of other filthy conditions. In fact, the water, and everything connected with it, seemed to be in an ideal state.

The statement has also been made that owing to the fact that the college at different intervals used the supply from the spring, and in this way became contaminated. An investigation made of the college spring water, as well as the different hydrants and cisterns, those of Professor Stanton, Professor Curtiss, and the old Sexton well, indi-

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Experimental Investigations St. Brd. Health, Massachusetts, **1889-1890**: 836, and later found by Moore to be widely distributed in the soil.

Russell and Bassett. Trans. Amer. Pub. Health Asso., **25**.

cate unusually good water, with the exception that in the Curtiss well and the Sexton well gas was produced, but this undoubtedly came from the surface soil. The spring water showed no gas whatever, nor was any obtained from the hydrant which was next to the spring. The samples and plates were carefully plated.

BACTERIA FOUND IN OTHER WATER SUPPLIES.

We have found quite commonly in all of our waters the *B. liquefaciens-fluorescens.* The *Tyrothrix* of Duclaux is certainly also common. Most attention has been given to the chromogenes. The common genera of Bacillus and Micrococcus were represented, and of the these the Micrococci were found more frequently than the Bacilli of these *Micrococcus roseus-flavus*, Hefferan, *M. agilis*, A. Cohn, and others were found.

BACILLUS TYPHOSUS IN WATER.

Now, as to the relative vitality of *Bacillus typhosus* in water; many determinations have been made, and it would not be strange if the *Bacillus typhosus* should not be found in water.

It is usually held by sanitarians that water is the most frequent source of infection. The evidence of *B. typhosus* in water, in most cases, is circumstantial; but I recall a case where Dr. Ravold found it in Mississippi river water, and bacteriological journals report cases of its occurrence in wells and streams, but the reported findings of the organism under such circumstances are not numerous. It is very evident that the typhoid fever bacillus will not grow in the ordinary media with other pathogenic organisms, nor are the special media much more satisfactory. It is evident from the results obtained from several investigators that not much can be expected from the organism after four weeks. It is certain that the typhoid fever organism will not multiply freely in water.

MILK AS A SOURCE OF CONTAMINATION.

As to the bacteria found in the milk supply, an investigation has been made, but this work was not completed,

owing to the destruction by fire of all of our cultures. We found present in the milk a large number of chromogenes, but none of these, of course, can be referred to, or are in any way related to the typhoid fever bacillus. On the other hand, we did find *B. coli-communis*, but it does not necessarily follow that the *B. coli-communis* comes from human dejecta, as this organism is very commonly found in connection with cow stables, and the organism being found quite frequently in the intestinal tract of animals as well as man. Therefore this cannot be considered to be the cause, nor as an argument against the use of milk. This work, however, was not completed, and hence a final statement cannot be made.

COMPARISON WITH THE SEWAGE BACTERIA.

The results of the work carried on on the College Sewage Plant show the following conditions with reference to the purification, and it is of interest to compare these results with the water obtained from the Briley well. It will be seen that in every case, excepting the last one, that the Briley well contained many times more organisms than the effluent of either filter bed.

DATE	From	Air	Water	Manhole	Tank	Effluent
September 1st	W. E.	90 degrees	75 degrees	....	....	960
September 2d	W. E.	72 degrees	71 degrees	....	....	2,400
September 3d	E. E.	62 degrees	73 degrees	....	....	2,100
September 4th	W. E.	63 degrees	72 degrees	....	....	390
September 5th	E. E.	82 degrees	72 degrees	....	....	230
September 5th	Tank	....	68 degrees	....	242,400	....
September 5th	Manhole	....	68 degrees	1,212,000	....	....
September 6th	W. E.	83 degrees	72 degrees	....	....	1,800
September 7th	W. E.	82 degrees	74 degrees	....	....	460
September 8th	W. E.	90 degrees	74 degrees	....	....	230
September 9th	E. E.	87 degrees	74 degrees	....	....	310
September 10th	Tank	....	....	....	424,200	....
September 10th	Manhole	....	62 degrees	1,363,000	....	....
September 10th	E. E.	68 degrees	72 degrees	....	....	210
September 11th	E. E.	69 degrees	73 degrees	....	....	440
September 12th	W. E.	70 degrees	74 degrees	....	....	110
September 13th	W. E.	84 degrees	72 degrees	....	....	1,200
September 14th	W. E.	85 degrees	74 degrees	....	....	480
September 15th	W. E.	55 degrees	74 degrees	....	....	100
September 16th	E. E.	65 degrees	72 degrees	....	....	320
September 17th	E. E.	68 degrees	70 degrees	....	....	3,600
September 17th	Tank	....	64 degrees	....	484,600	....
September 17th	Manhole	....	68 degrees	696,600	....	....
September 18th	W. E.	50 degrees	64 degrees	....	....	460
September 19th	W. E.	66 degrees	65 degrees	....	....	340
September 20th	E. E.	72 degrees	67 degrees	....	....	420
September 21st	W. E.	71 degrees	67 degrees	....	....	340
September 22d	E. E.	79 degrees	66 degrees	....	....	480

From September 23d to September 28th, inclusive, the sewage effluent pipe was under water, hence no samples.

DATE.	From	Air	Water	Manhole	Tank	Effluent
September 29th	E. E	69 degrees	64 degrees			980
September 30th	W. E	68 degrees	64 degrees			460
October 1st	W. E	72 degrees	65 degrees			360
October 1st	Tank		67 degrees		568.400	
October 1st	Manhole			896,600		
October 2d	W. E	80 degrees	67 degrees			1,200
October 3d	E. E	75 degrees	67 degrees			360
October 4th	W. E	81 degrees	67 degrees			1,800
October 5th	E. E	80 degrees	67 degrees			450
October 6th	E. E	72 degrees	68 degrees			1,200
October 7th	W. E	63 degrees	68 degrees			2,100
October 8th	E. E	40 degrees	68 degrees			1,800
October 8th	Tank		62 degrees		260,000	
October 8th	Manhole		61 degrees	1,333,200		
October 9th	W. E	63 degrees	70 degrees			2,400

From 10th to 13th, inclusive, the beds were being cleaned and the sewage was turned directly into the creek from the tank.

October 14th	W. E	63 degrees	63 degrees			360
October 15th	W. E	63 degrees	63 degrees			210
October 15th	Tank		63 degrees		1,2r2,000	
October 15th	Manhole		64 degrees	*		
October 16th	W. E	60 degrees	62 degrees			120
October 17th	W. E	55 degrees	62 degrees			120
October 18th	E. E	63 degrees	61 degrees			130

* Too thick to count. Estimated at 5,000,000.

CONCLUSION.

It may be stated that so far as the analysis show the college water supply may be considered excellent. It is true that in a number of instances more organisms were found than at other times, but an examination made from time to time shows that the number is not unusually large, and on the whole that we may consider our water supply practically pure, and I should also state that the water from the spring supply is unusually good. We should bear in mind that the failure to find the typhoid fever bacillus in the water supply or milk of the Briley well is not at all surprising. It is a well known fact that the saprophytic species grow so readily in the nutrient media that the typhoid fever bacillus has not the same chance to grow. The same may also be said with reference to milk, only here we are dealing with such a large

number of species that it would be a mere accident to discover the organism. As said heretofore it seems to me to be reasonable that the milk formed a favorable medium for the growth of the organism, and be it specially remembered that Mr. Briley, from his own testimony, failed to wash the cans with boiling water as should have been done. The milk cans could easily have been contaminated, and the failure on his part to wash the cans, it seems to me, made it not only possible but probable that these germs propagated in the milk.

A comparison of the water of the Briley well and the college effluent shows that the Briley well had a greater amount of contamination than the college effluent from the sewage filter beds.

DRIFT EXPOSURE IN TAMA COUNTY.

BY T. E. SAVAGE.

A few months ago, in making some improvements in the roadbed of the Chicago & Northwestern Railroad, a deep cut was made in a hill about three miles west of the city of Toledo, in Tama county, Iowa, where the following section was exposed:

5.	Fine grained, yellowish colored loess clay without gravel or bowlders	4½
4.	Bed of sand in alternating bands of finer and coarser grained material	8
3.	Bed of clay, containing numerous pebbles and bowlders	24
2.	Band of brown colored, somewhat sandy soil, containing impressions of vegetable remains and a few bits of wood,	1½
1.	Bed of bluish colored clay, with numerous pebbles and bowlders down to the base of the exposure	16

In the section given above, Number 5 is the common fine grained loess that forms the surface soil over most of the neighboring region. It contains no pebbles nor bowlders, nor any calcareous matter, as shown by the want of action when treated with hydrochloric acid. It is of a yellowish color in the upper part, becoming tinged with brown in the central and lower portions.

Number 4 is a bed of loose sand, in which the layers of finer grained material alternating with those of coarser texture indicate a deposit along the bed of a stream in which the strength of the current was variable. This sand bed contains no trace of calcium carbonate throughout its entire thickness. It was probably laid down by the waters which resulted from the melting of the Kansan ice.

Number 3 is a thick bed of clay, which bears numerous pebbles and bowlders of various sizes. Many of the lighter colored bowlders have partially decayed, and are so rotten that they can be broken apart with the hands. For a depth of four feet from the top the material has a somewhat reddish appearance. This color gradually changes with the depth through yellow and gray to the bluish color of the main body of clay. In the upper portion are several pockets and lentils of rather fine-grained sand. The bed is cut by numerous joints and cracks into prismatic and irregularly shaped blocks and fragments. It is calcareous throughout, hydrochloric acid producing vigorous effervescence at the very top, immediately below the layer of sand, as well as in every portion of its depth.

Number 2 is a layer very different in character from that which overlies it, or from that which is found below. It is dark brown in color and is largely composed of more or less perfectly decayed vegetable matter mixed with a soil which contains a considerable amount of sand. Near the upper portion of this layer may be found a few fragments of wood and bits of roots and darker colored patches of carbonaceous material. The bed contains no trace of calcareous matter. It forms a conspicuous band eighteen to twenty-four inches in thickness, which is exposed at this horizon for a distance of forty rods.

Number 1 is a bed of drift which resembles in many respects Number 3 above. Many of the pebbles and bowlders which it carries are beautifully polished and striated. In the lower portion it is bluish gray in color, but to a depth of three or four feet from the top the clay has a slightly reddish tinge. This red color, however, is not so marked as in the oxidized surface materials of the

Kansan drift. This bed is not cut up into irregular blocks by the presence of such numerous joints and cracks as appear in the clay found in Number 3 above. At the top of this number, just below the soil band, the calcareous matter has been entirely leached out for a depth of eighteen to twenty-four inches. At a depth of thirty inches from the top there is in some places a slight action in response to hydrochloric acid, and in the other places at

Fig. 16. Drift exposure along the C. & N. W. Ry., near Toledo, Iowa.

the same depth the acid produces no action whatever. At a depth of three feet the acid usually produces slight effervescence. At four feet in depth the action with acid is still stronger than at three, while at a depth of six feet from the top, and so on down to the base of the exposure, the acid never fails to produce a prompt and vigorous action.

CONCLUSION.

In the above exposure the following conditions seem to indicate the presence of two different drift sheets.

First. Buried soil: Lying between two thick beds of drift there is an apparent soil horizon, dark brown in color, in which are imbedded numerous small bits of wood and darker colored fragments of organic matter.

Second. Leaching. The bed of clay which overlies the soil horizon is very calcareous to the base. The soil band contains no trace of calcareous matter, nor does any such material appear for a depth of two feet below it. At a depth of thirty inches a slight quantity is present in the clay. This quantity gradually increases with the depth until at six feet below the soil band and from there to the base of the exposure the quantity is considerable as shown by the vigorous action with acid. This would indicate a long interval during which the old soil band was at the surface and subjected to the leaching effects of the atmosphere and of percolating water before it was buried by the overlying materials which were carried by a later sheet of ice.

Third. Oxidized zone. The reddish color of the clay to a depth of three or four feet below the soil horizon would indicate a period during which these materials were exposed to the oxidizing effects of the air. The oxidation resulted in the changing of the iron found in the clay from the form of carbonate, in which form it usually occurs in the blue clays, to that of the oxide known as hematite, in which form it imparts a reddish color to the clays when it is present.

The above exposure is about eight miles south of the border of the Iowan drift plain, and is within the area in which the Kansan drift forms the surface materials. It is thought by the writer, that Number 3 of the exposure represents the Kansan drift; Number 2, the soil horizon which represents the Aftonean interglacial period, while Number 1 is referred to the bowlder clay of the pre-Kansan drift sheet with its upper portion leached and partially oxidized as described above.